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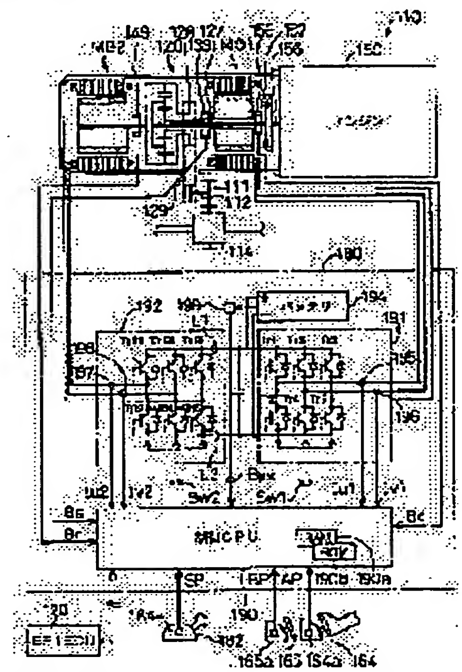
(54) POWER OUTPUT DEVICE, PRIME MOVER CONTROL DEVICE AND CONTROL METHOD THEREFOR

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce the rotating speed of a prime mover rapidly to the value zero at the time of stopping the operation of the prime mover in a power output device composed of the prime mover, a triaxial power input-output means and two motors.
SOLUTION: A power output device 110 is provided with a planetary gear 120, an engine 150 with a crankshaft 156 connected to the planetary gear 120, a motor MG1 fitted to a sun gear, and a motor MG2 fitted to a ring gear. When the stop of the engine 150 is commanded, fuel injection to the engine 150 is stopped, and the motor MG1 is so controlled that torque in a reverse direction to the rotating direction of the crankshaft 156 acts upon the crankshaft 156 through the planetary gear 120 and a carrier shaft 127 until the rotating speed of the engine 150 becomes close to the value zero. As a result, the rotating speed of the engine 150 can be rapidly reduced to the value zero.



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CLAIMS

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(57) [Claim(s)]
[Claim 1] A power output unit which is characterized by providing the following and which outputs power to a driving shaft A prime mover which has an output shaft The 1st motor which has the axis of rotation, and outputs and inputs power to this axis of rotation The 2nd motor which outputs and inputs power to said driving shaft When it has three shafts respectively combined with said driving shaft, said output shaft, and said axis of rotation and power is outputted and inputted among these three shafts to any 2 shafts, A 3 shaft type power I/O means to output and input power which becomes settled based on this power outputted and inputted to one residual shaft, A fuel stop order means to direct to suspend fuel supply to this prime mover when conditions which should suspend operation of said prime mover are ready, An aim torque storage means to define beforehand desired value to which said motor met elapsed time of torque added to said output shaft based on behavior at the time of a halt of said prime mover at the time of a halt of said prime mover, With directions of a halt of fuel supply to this prime mover, drive said motor and through said 3 shaft type power I/O means by adding torque according to said desired value to said output shaft in accordance with elapsed time after a halt of said prime mover A halt tense activation means to perform control at the time of a halt which controls rotation deceleration of this output shaft in a predetermined range, and suspends said prime mover
[Claim 2] A power output unit which is characterized by providing the following and which outputs power to a driving shaft A prime mover which has an output shaft The 1st motor which has the axis of rotation, and outputs and inputs power to this axis of rotation The 2nd motor which outputs and inputs power to said driving shaft When it has three shafts respectively combined with said driving shaft, said output shaft, and said axis of rotation and power is outputted and inputted among these three shafts to any 2 shafts, A 3 shaft type power I/O means to output and input power which becomes settled based on this power outputted and inputted to one residual shaft, A fuel stop order means to direct to suspend fuel supply to this prime mover when conditions which should suspend operation of said prime mover are ready, A halt tense activation means to perform control at the time of a halt which torque is added to said output shaft, and rotational speed of this output shaft is dropped with directions of a halt of fuel supply to this prime mover in accordance with inclination beforehand defined with time amount from a halt of said prime mover, and suspends said prime mover
[Claim 3] A power output unit according to claim 1 characterized by providing the following A decelerating operation means to search for deceleration of a rotational frequency of said output shaft under activation of control at the time of said halt A study means to fluctuate a study value by size of said deceleration searched for, and to memorize A decelerating range decision means to determine said predetermined range in control based on said memorized study value at the time of said halt of said halt tense activation means
[Claim 4] It is the power output unit equipped with a means to perform control which drives said 1st motor so that said halt tense activation means may serve as a predetermined value in a path predetermined in a rotational frequency of said output shaft detected by said rotational frequency detection means as control at the time of said halt while having a rotational frequency detection means to be a power output unit according to claim 1, and to detect a rotational frequency of said output shaft.
[Claim 5] While having a rotational frequency detection means to be a power output unit according to claim 1, and to detect a rotational frequency of said output shaft, said halt tense means At the time of said halt, as control, until a rotational frequency of said output shaft detected by said rotational frequency detection means serves as a predetermined value A power output unit equipped with a means to perform control which drives said 1st motor so that torque of reverse sense may be added to this output shaft with a hand of cut of this output shaft through said 3 shaft type power I/O means.
[Claim 6] When said halt tense means becomes as a part of control below a decision value by which an assignment setup of the rotational frequency of said output shaft detected by said rotational frequency detection means was carried

out with a value below said predetermined value at the time of said halt, A power output unit [equipped with a means to perform control which drives said 1st motor so that predetermined torque which acts on a hand of cut of this output shaft through said 3 shaft type power I/O means may be added to this output shaft] according to claim 5.
[Claim 7] A power output unit equipped with a decelerating operation means to be a power output unit according to claim 5, and to search for deceleration of a rotational frequency of said output shaft under activation of control at the time of said halt, and a decision value setting means to set said decision value as a big value, so that an absolute value of this deceleration is large.
[Claim 8] A power output unit equipped with a damping force judging means to be a power output unit according to claim 5, and to judge size of damping force which joins said driving shaft during activation of control at the time of said halt, and a decision value setting means to set said decision value as a big value when judged with this damping force being large.
[Claim 9] Said predetermined value is a power output unit according to claim 5 which is the rotational frequency which is less than a resonance field of torsional oscillation of a system including said output shaft and said triaxial type power I/O means.
[Claim 10] A power output unit which is a power output unit according to claim 1, and is equipped with the 2nd motor control means which drives said 2nd motor and continues I/O of power to said driving shaft when directions of shutdown of said prime mover are made, where I/O of power to said driving shaft is continued.
[Claim 11] It has a prime mover which outputs power by combustion of a fuel characterized by providing the following, and a motor connected to an output shaft of this prime mover through a damper, and is a controllable prime-mover control unit about operation and a halt of this prime mover. A fuel means for stopping which suspends fuel supply to this prime mover when conditions which should suspend operation of said prime mover are ready An aim torque storage means to define beforehand desired value to which said motor met elapsed time of torque added to said output shaft based on behavior at the time of </** U> ** of said prime mover at the time of a halt of said prime mover A halt tense activation means to perform control at the time of a halt which drives said motor, controls rotation deceleration of this output shaft by adding torque according to said desired value to said output shaft in accordance with elapsed time after a halt of said prime mover in a predetermined range with directions of a halt of fuel supply to this prime mover, and suspends said prime mover
[Claim 12] Desired value in alignment with elapsed time of torque which is a prime-mover control unit according to claim 11, and said motor adds to said output shaft at the time of a halt of said prime mover While having an aim torque storage means beforehand defined based on behavior at the time of a halt of said prime mover, said halt tense activation means A prime-mover control unit equipped with a means to perform control which drives said motor so that torque according to said desired value may be added to said output shaft in accordance with elapsed time after a halt of said prime mover as control at the time of said halt.
[Claim 13] A prime-mover control unit according to claim 12 characterized by providing the following A decelerating operation means to search for deceleration of a rotational frequency of said output shaft under activation of control at the time of said halt A study means to fluctuate a study value by size of said deceleration searched for, and to memorize A decelerating range decision means to determine said predetermined range in control based on said memorized study value at the time of said halt of said halt tense activation means
[Claim 14] It is the prime-mover control unit equipped with a means to perform control which drives said motor so that said halt tense activation means may serve as a predetermined value in a path predetermined in a rotational frequency of said output shaft as control at the time of said halt while having a rotational frequency detection means to be a prime-mover control unit according to claim 11, and to detect a rotational frequency of said output shaft.
[Claim 15] Said halt tense activation means is a prime-mover control unit with which a hand of cut of this output shaft is equipped with a means perform control to which said motor is driven so that torque of reverse sense may be added to this output shaft until a rotational frequency of said detected output shaft serves as a predetermined value as control while having a rotational frequency detection means are a prime-mover control unit according to claim 11, and detect a rotational frequency of said output shaft at the time of said halt.
[Claim 16] While having a rotational frequency detection means to be a prime-mover control unit according to claim 11, and to detect a rotational frequency of said output shaft, said halt tense means When a rotational frequency of said output shaft detected by said rotational frequency detection means becomes as a part of control below a decision value set up as a value below said predetermined value at the time of said halt, A prime-mover control unit equipped with a means to perform control which drives said motor so that predetermined torque which acts on a hand of cut of this output shaft may be added to this output shaft.
[Claim 17] A prime-mover control unit equipped with a decelerating operation means to be a prime-mover control unit

according to claim 15, and to search for deceleration of a rotational frequency of said output shaft under activation of control at the time of said halt, and a decision value setting means to set said decision value as a big value, so that an absolute value of this deceleration is large.

[Claim 18] Said predetermined value is a driving gear according to claim 15 which is the rotational frequency which is less than a resonance field of torsional oscillation of a system containing said output shaft and rotator of said motor.

[Claim 19] It is the method of controlling a power output unit by which it is characterized by providing the following. When conditions which should suspend operation of said prime mover are ready, it points so that fuel supply to this prime mover may be suspended. Desired value in alignment with elapsed time of torque which said motor adds to said output shaft at the time of a halt of said prime mover Based on behavior at the time of a halt of said prime mover, set beforehand, drive said motor with directions of a halt of fuel supply to this prime mover, and said 3 shaft type power I/O means is minded. A control method of a power output unit of performing control at the time of a halt which controls rotation deceleration of this output shaft by adding torque according to said desired value to said output shaft in accordance with elapsed time after a halt of said prime mover in a predetermined range, and suspends said prime mover by it A prime mover which has an output shaft The 1st motor which has the axis of rotation, and outputs and inputs power to this axis of rotation The 2nd motor which outputs and inputs power to said driving shaft A 3 shaft type power I/O means to output and input power which becomes settled based on power outputted and this inputted when it has three shafts respectively combined with said driving shaft, said output shaft, and said axis of rotation and power is outputted and inputted among these three shafts to any 2 shafts to one residual shaft

[Claim 20] It is the prime mover which outputs power by combustion of a fuel, and is the method of controlling a halt of a prime mover equipped with a motor connected to an output shaft of this prime mover through a damper. When conditions which should suspend operation of said prime mover are ready, fuel supply to this prime mover is suspended. Desired value in alignment with elapsed time of torque which said motor adds to said output shaft at the time of a halt of said prime mover Based on behavior at the time of a halt of said prime mover, set beforehand, and it follows on directions of a halt of fuel supply to this prime mover. A control method of a prime mover of performing control at the time of a halt which drives said motor, controls rotation deceleration of this output shaft by adding torque according to said desired value to said output shaft in accordance with elapsed time after a halt of said prime mover in a predetermined range, and suspends said prime mover.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to these control methods at the technology and the list which suspend a prime mover in the power output unit which outputs power to the technology and the driving shaft which suspend a prime mover in the system which consists of a prime-mover control unit and the motor which were connected to the output shaft of the prime mover which outputs power by combustion of a fuel, and this prime mover through a damper in detail about these control methods at a power output unit list.
[0002]
[Description of the Prior Art] Conventionally, the thing which comes to combine the torque converter using a fluid and a change gear as a power output unit which carries out torque conversion of the power outputted from a prime mover, and is outputted to a driving shaft was used. The torque converter in this equipment transmits power between both shafts through fluid of the fluid which has been arranged and was enclosed between the axes of rotation combined with the output shaft and change gear of a prime mover. Thus, in a torque converter, in order to transmit power by fluid of a fluid, slipping arises among both shafts and the energy loss according to this slipping occurs. Correctly, this energy loss is expressed with a product with the torque then delivered the rotational frequency difference of both shafts to the output shaft of power, and is consumed as heat.
[0003]
[Problem(s) to be Solved by the Invention] Therefore, by the vehicles which carry such a power output unit as a source of power, when large power was required like [when slipping between both shafts becomes large (for example, when running the time of start and ascent inclination at a low speed)], there was a problem that the energy loss in a torque converter became large, and became what has low energy efficiency. Moreover, since the transmission efficiency of the power in a torque converter does not become 100% even if it is at the stationary transit time, for example compared with the transmission of manual system, the fuel consumption cannot but become low.
[0004] The power output unit and its control method of this invention solve an above-mentioned problem, and set to one of the purposes to offer the equipment which outputs the power outputted from a prime mover to a driving shaft efficient, and the control method of the equipment.
[0005] In view of an above-mentioned problem, not using the torque converter using a fluid, the applicant had a prime mover, the epicyclic gear drive as a 3 shaft type power I/O means, the generator, the motor, and the battery, and has proposed what outputs the power outputted from a motor using the power stored in the power outputted from a prime mover, or a battery to a driving shaft (the Provisional-Publication-No. No. 30223 [50 to] official report). However, by this proposal, it is not clearly shown about the control when suspending operation of a prime mover.
[0006] Then, the power output unit and its control method of this invention set to one of the purposes to offer the technique of the control at the time of suspending operation of the prime mover in the power output unit which consists of a prime mover, a 3 shaft type power I/O means, and two motors.
[0007] Moreover, since the output shaft of a prime mover and the axis of rotation of a motor are mechanically combined by 3 shaft type power I/O means, this power output unit constitutes one vibration system mechanically. If it follows, for example, the torque fluctuation by the reciprocating motion of the gas explosion in an internal combustion engine or a piston is added when a prime mover is an internal combustion engine, torsional oscillation will arise in an internal combustion engine's output shaft or the axis of rotation of a motor, if the resonant frequency and forced frequency of a shaft are in agreement, resonance phenomena are caused, an allophone will be produced from 3 shaft type power I/O means, or fatigue breaking of a shaft will be produced depending on the case. Although such resonance phenomena change with the class of prime mover, structures of 3 shaft type power I/O means, etc., they are produced in the

condition of under the minimum engine speed that can operate a prime mover in many cases.
[0008] Then, in case the power output unit and its control method of this invention suspend operation of a prime mover, they set to one of the purposes to prevent the resonance phenomena of the torsional oscillation which may be produced in a system.
[0009] Moreover, when torque is outputted to the output shaft of a prime mover from a motor and a prime mover is stopped positively, depending on control of a motor, the rotational frequency of the output shaft of a prime mover may undershoot, and may become zero or less value, and vibration may arise to the whole equipment in this case. Therefore, when this driving gear is carried in vehicles, the vibration in the case of undershoot gives propagation to the body, and gives an operator sense of incongruity.
[0010] Then, the driving gear and its control method of this invention set to one of the purposes to reduce vibration which may be produced in case operation of a prime mover is suspended.
[0011] The problem of the resonance phenomena of the torsional oscillation which may be produced in a system in case operation of such a prime mover is suspended is not restricted to an above-mentioned power output unit, but if the output shaft of a prime mover and the axis of rotation of a motor are the driving gears combined mechanically, it may be produced similarly. There is much equipment which combines mechanically the output shaft of a prime mover and the axis of rotation of a motor through a damper to this problem. However, if the effect of stopping the amplitude of torsional oscillation uses a big damper, such a damper will be enlarged while the number of components increases, since it has a special damping function. On the other hand, if a small and simple damper is used, the effect of stopping the amplitude of torsional oscillation will become small.
[0012] The configuration which has this problem links directly not only a configuration but the prime mover and generator which output power directly, and the so-called series hybrid which acquires the torque for transit with the motor by the power generated with this generator to drive corresponds. Therefore, invention of a prime-mover control unit and its control method was made as invention with same power output unit and principal part with the above. In case this prime-mover control unit and its control method are not based on the class of damper but suspend operation of a prime mover, they set to one of the purposes to prevent the resonance phenomena of the torsional oscillation which may be produced in a system.
[0013]
[The means for solving a technical problem, and its operation and effect] In the power output unit of this invention, and the prime-mover control method list, these control methods took the following means, in order to attain a part of above-mentioned purpose [at least].
[0014] The prime mover which the power output unit of this invention is a power output unit which outputs power to a driving shaft, and has an output shaft, The 1st motor which has the axis of rotation, and outputs and inputs power to this axis of rotation, and the 2nd motor which output and input power to said driving shaft, When it has three shafts respectively combined with said driving shaft, said output shaft, and said axis of rotation and power is outputted and inputted among these three shafts to any 2 shafts, A 3 shaft type power I/O means to output and input the power which becomes settled based on the this power outputted and inputted to one residual shaft, A fuel stop order means to direct to suspend the fuel supply to this prime mover when the conditions which should suspend operation of said prime are ready, An aim torque storage means to define beforehand the desired value to which said motor met the elapsed time of the torque added to said output shaft based on the behavior at the time of a halt of said prime mover at the time of a halt of said prime mover, With directions of a halt of the fuel supply to this prime mover, drive said motor and through said 3 shaft type power I/O means by adding the torque according to said desired value to said output shaft in accordance with the elapsed time after a halt of said prime mover Let it be a summary to have a halt tense activation means to perform control at the time of a halt which controls the rotation deceleration of this output shaft in a predetermined range, and suspends said prime mover.
[0015] Moreover, the control method of the power output unit corresponding to this power output unit The prime mover which has an output shaft, and the 1st motor which have the axis of rotation, and output and input power to this axis of rotation, When it has three shafts respectively combined with the 2nd motor which outputs and inputs power to said driving shaft, and said driving shaft, said output shaft and said axis of rotation and power is outputted and inputted among these three shafts to any 2 shafts, It is the method of controlling the power output unit equipped with a 3 shaft type power I/O means to output and input the power which becomes settled based on the this power outputted and inputted to one residual shaft. When the conditions which should suspend operation of said prime mover are ready, it points so that the fuel supply to this prime mover may be suspended. The desired value in alignment with the elapsed time of the torque which said motor adds to said output shaft at the time of a halt of said prime mover Based on the behavior at the time of a halt of said prime mover, set beforehand, drive said motor with directions of a halt of the fuel

supply to this prime mover, and said 3 shaft type power I/O means is minded. It is making into the summary to perform control at the time of a halt which controls the rotation deceleration of this output shaft by adding the torque according to said desired value to said output shaft in accordance with the elapsed time after a halt of said prime mover in a predetermined range, and suspends said prime mover by it.
[0016] if the conditions which should suspend operation of a prime mover are ready according to this power output unit and its control method, it is directed that a power output unit suspends the fuel supply to a prime mover -- control is both performed at the time of a halt. At the time of this halt, control defines beforehand the desired value to which this motor met the elapsed time of the torque added to an output shaft based on the behavior at the time of a halt of a prime mover at the time of a halt of a prime mover, adds this torque at the time of the output of a prime mover, restricts the deceleration of this output shaft to a predetermined range, and suspends a prime mover. Addition of the torque to an output shaft is good also by the 1st motor, and good also by the 2nd motor.
[0017] Consequently, the deceleration of an output shaft is restricted to a predetermined range, for example, becomes controllable [of passing through a torsion resonance field quickly]. It also becomes possible to avoid the unnecessary power consumption in a motor to coincidence.
[0018]
[0019] In this case, since feedback control using the rotational frequency of an output shaft is not performed, there is nothing about changing a torque command value according to the condition and disturbance of a power output unit, and the torque fluctuation in a driving shaft can be reduced. Moreover, even when the rotational frequency of an output shaft is greatly far apart from the aim rotational frequency (it is usually a value 0 when it is a halt), since feedback control based on a rotational frequency difference is not performed, it is not said that an excessive torque command value will be outputted and unnecessary power will be consumed.
[0020] Although a double lump is needed in this open loop control in order to realize optimal control from not acting feedback control For example, a decelerating operation means to search for the deceleration of the rotational frequency of said output shaft under activation of control at the time of said halt, If a study value is fluctuated by the size of said deceleration searched for and a study means to memorize, and a decelerating range decision means to determine said predetermined range in control based on said memorized study value at the time of said halt of said halt tense activation means are established Since the range of decelerating can be learned, good control is realizable.
[0021] Furthermore, as other examples of a configuration of control, the control which drives said 1st motor so that the rotational frequency of said output shaft detected by the rotational frequency detection means may serve as a predetermined value in a predetermined path can be considered at the time of a halt. Here, a predetermined path means transition of the rotational frequency of the output shaft of a prime mover to the time amount of a from, when the fuel supply to a prime mover is suspended. A path which drops the rotational speed of an output shaft in accordance with the inclination defined beforehand as an example with the time amount from a halt of said prime mover can be defined beforehand. [0022] According to such a power output unit, when directions of the shutdown of a prime mover are made, the rotational frequency of the output shaft of a prime mover can be made into a predetermined value in a desired path. Therefore, the rotational frequency of the axis of rotation of a prime mover can be quickly made into a predetermined value, and the rotational frequency of the thing from which the rotational frequency of the output shaft of a prime mover serves as a predetermined value in a predetermined path for a short time, the thing which makes a predetermined path a predetermined value over many hours comparatively, then the axis of rotation of a prime mover can be gently made into a predetermined value. Furthermore, rotation of a value 0, then the output shaft of a prime mover can be stopped for a predetermined value quickly or gently.
[0023] In this power output unit, as control, control which drives said 1st motor so that the hand of cut of this output shaft may add the torque of the reverse sense to this output shaft shall be performed through said 3 shaft type power I/O means at the time of a halt until the rotational frequency of said output shaft detected by said rotational frequency detection means serves as a predetermined value. If it carries out like this, the rotational frequency of the output shaft of a prime mover can be more quickly made into a predetermined value. Therefore, when the resonance field of torsional oscillation is between the rotational frequency of the output shaft of a prime mover when directions of the shutdown of a prime mover are made, and a predetermined value, it can pass through this field quickly and resonance phenomena can be prevented.
[0024] Moreover, when the rotational frequency of said output shaft detected by said rotational frequency detection means becomes as a part of control in this power output unit below the decision value set up as a value below said predetermined value at the time of a halt, Control which drives said 1st motor so that the predetermined torque which acts on the hand of cut of this output shaft through said 3 shaft type power I/O means may be added to this output shaft shall be performed. If it carries out like this, the undershoot which may be produced in case rotation of an output shaft is

suspended can be controlled, and vibration which may be produced in that case can be reduced.
[0025] Here, as how to calculate a decision value, although various methods can take, the deceleration of the rotational frequency of said output shaft under activation of control is searched for at the time of a halt, for example, and it is good also as what sets a decision value as a big value, so that a decelerating absolute value is large. By enlarging a decision value, it can prevent beforehand that the rotational frequency of an output shaft undershoots, so that deceleration is large. Moreover, when the size of damping force which joins said driving shaft during activation of control at the time of a halt is judged and it is judged with this damping force being large, a decision value shall be set as a big value. Since it can consider that the force which stops a prime mover is large when damping force is added, the undershoot of a rotational frequency can be prevented by enlarging a decision value.
[0026] Furthermore, in the power output unit of this invention, said halt tense means shall be a means which carries out drive control of said 1st motor so that the power outputted and inputted by said axis of rotation may serve as a value 0. If it carries out like this, since there is no consumption of the power by the 1st motor, the energy efficiency of the whole equipment can be raised. Moreover, since operational status of the output shaft of a prime mover is not compulsorily changed with the 1st motor, the torque shock accompanying the shutdown of a prime mover can be reduced. In addition, as for a prime mover and the 1st motor, the sum of the energy (for example, friction work etc.) consumed by each settles down by the operational status used as min.
[0027] Or in the power output unit of this invention, if it considers as the rotational frequency which is less than the resonance field of the torsional oscillation of the system which includes an output shaft and a triaxial type power I/O means for said predetermined value and can set, prevention of torsion resonance can be ensured.
[0028] Furthermore, where I/O of the power to said driving shaft is continued, when directions of the shutdown of a prime mover are made, said 2nd motor shall be driven and I/O of the power to said driving shaft shall be continued. If it carries out like this, operation of a prime mover can be suspended to the midst which is continuing I/O of the power to a driving shaft. And the 2nd motor can perform I/O of the power to a driving shaft.
[0029] Next, the outline of the prime-mover control unit of the invention in this application is explained. The prime mover to which the prime-mover control unit of the invention in this application outputs power by combustion of a fuel, It has the motor connected to the output shaft of this prime mover through the damper, and is a controllable prime-mover control unit about operation and a halt of this prime mover. The fuel means for stopping which suspends the fuel supply to this prime mover when the conditions which should suspend operation of said prime mover are ready, An aim torque storage means to define beforehand the desired value to which said motor met the elapsed time of the torque added to said output shaft based on the behavior at the time of a halt of said prime mover at the time of a halt of said prime mover, By driving said motor and adding the torque according to said desired value to said output shaft in accordance with the elapsed time after a halt of said prime mover with directions of a halt of the fuel supply to this prime mover It is making into the summary to have had a halt tense activation means to perform control at the time of a halt which controls the rotation deceleration of this output shaft in a predetermined range, and suspends said prime mover.
[0030] Moreover, the control method of the prime mover corresponding to this prime-mover control method It is the prime mover which outputs power by combustion of a fuel, and is the method of controlling a halt of the prime mover equipped with the motor connected to the output shaft of this prime mover through the damper. When the conditions which should suspend operation of said prime mover are ready, the fuel supply to this prime mover is suspended. The desired value in alignment with the elapsed time of the torque which said motor adds to said output shaft at the time of a halt of said prime mover Based on the behavior at the time of a halt of said prime mover, set beforehand, and it follows on directions of a halt of the fuel supply to this prime mover. It is making into the summary to perform control at the time of a halt which drives said motor, controls the rotation deceleration of this output shaft by adding the torque according to said desired value to said output shaft in accordance with the elapsed time after a halt of said prime mover in a predetermined range, and suspends said prime mover.
[0031] The control method of this prime-mover control unit and a prime mover can control a halt of the prime mover by which the motor was connected to the output shaft through the damper, and can reduce the torsion resonance which may be produced in the output shaft of the prime mover to which the motor was connected through the damper. namely, by the control method of this prime-mover control unit and a prime mover When the conditions by which the desired value to which the motor met the elapsed time of the torque added to an output shaft is beforehand provided based on the behavior at the time of a halt of a prime mover at the time of a halt of a prime mover and which should suspend operation of a prime mover are ready, Supply of the fuel for a prime mover is suspended, in connection with this, to the output shaft of a prime mover, the torque according to this desired value is added, the rotation deceleration of an output shaft is restricted to a predetermined range, and a prime mover is suspended. Since it is easy to produce torsion

resonance of an output shaft with predetermined deceleration, torsion resonance is reduced by restricting the rotation deceleration of an output shaft to a predetermined range.
[0032] This control is the so-called open loop control, and sets up beforehand the desired value of the torque which a motor adds to an output shaft along with a time-axis at the time of a halt of a prime mover.
[0033] In this case, since feedback control using the rotational frequency of an output shaft is not performed, the torque added to an output shaft is not changed according to disturbance. Moreover, even when the rotational frequency of an output shaft is greatly far apart from the aim rotational frequency (it is usually a value 0 when it is a halt), since feedback control based on a rotational frequency difference is not performed, it is not said that excessive torque will be added to an output shaft and unnecessary power will be consumed.
[0034] Although a double lump is needed in this open loop control in order to realize optimal control from not acting feedback control For example, a decelerating operation means to search for the deceleration of the rotational frequency of said output shaft under activation of control at the time of said halt, A study means to fluctuate a study value by the size of said deceleration searched for, and to memorize, If it is made the configuration equipped with a decelerating range decision means to determine said predetermined range in control based on said memorized study value at the time of said halt of said halt tense activation means, since the range of decelerating can be learned, good control is realizable.

[0035] Furthermore, as other examples of a configuration of control, the control which drives a motor so that the rotational frequency of the output shaft detected by the rotational frequency detection means may serve as a predetermined value in a predetermined path can be considered at the time of a halt. Here, a predetermined path means transition of the rotational frequency of the output shaft of a prime mover to the time amount of a from, when the fuel supply to a prime mover is suspended.
[0036] According to such a prime-mover control unit, when directions of the shutdown of a prime mover are made, the rotational frequency of the output shaft of a prime mover can be made into a predetermined value in a desired path. Therefore, the rotational frequency of the axis of rotation of a prime mover can be quickly made into a predetermined value, and the rotational frequency of the thing from which the rotational frequency of the output shaft of a prime mover serves as a predetermined value in a predetermined path for a short time, the thing which makes a predetermined path a predetermined value over many hours comparatively, then the axis of rotation of a prime mover can be gently made into a predetermined value. If the range of decelerating is restricted so that the torsion resonance field of an output shaft may be avoided, in any case, it will twist to an output shaft, and resonance will not produce it.
[0037] Furthermore, at the time of a halt, as control, the hand of cut of an output shaft shall perform control which drives a motor so that the torque of the reverse sense may be added to an output shaft until the rotational frequency of the detected output shaft serves as a predetermined value. In this case, the rotational frequency of the output shaft of a prime mover can be more quickly made into a predetermined value. Therefore, when the resonance field of torsional oscillation is between the rotational frequency of the output shaft of a prime mover when directions of the shutdown of a prime mover are made, and a predetermined value, it can pass through this field quickly and resonance phenomena can be prevented.
[0038] Moreover, in this prime-mover control unit, when the rotational frequency of an output shaft becomes as a part of control below the decision value set up as a value below a predetermined value at the time of a halt, it is also possible to perform control which drives a motor so that the predetermined torque which acts on the hand of cut of an output shaft may be added to an output shaft. If it carries out like this, the undershoot which may be produced in case rotation of an output shaft is suspended can be controlled, and vibration which may be produced in that case can be reduced.
[0039] Here, as how to calculate a decision value, although various methods can take, it is good also as what sets a decision value as a big value, for example, so that the absolute value of the deceleration of the rotational frequency of the output shaft under activation of control is large at the time of a halt. By enlarging a decision value, it can prevent beforehand that the rotational frequency of an output shaft undershoots, so that deceleration is large.
[0040] In addition, if it considers as the rotational frequency which is less than the resonance field of the torsional oscillation of the system which includes a predetermined value for an output shaft and the rotator of a motor, generating of torsion resonance can be controlled certainly.
[0041]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained based on an example. The block diagram showing the outline configuration of the power output unit 110 with which drawing 1 contains the engine control system as one example of this invention, explanatory drawing in which drawing 2 shows the details configuration of the power output unit 110 of an example, and drawing 3 are the block diagrams showing the outline configuration of the vehicles incorporating the power output unit 110 of an example. It explains from the configuration

of the whole vehicles using drawing 3 first on account of explanation.
[0042] These vehicles are equipped with the engine 150 which outputs power by using a gasoline as a fuel as shown in drawing 3 . This engine 150 inhales the gaseous mixture of the air inhaled through the throttle valve 166 from the inhalation-of-air system, and the gasoline injected from the fuel injection valve 151 to a combustion chamber 152, and changes into rotation of a crankshaft 156 movement of the piston 154 depressed by explosion of this gaseous mixture. Here, the closing motion drive of the throttle valve 166 is carried out by the actuator 168. An ignition plug 162 forms a spark with the high voltage drawn through the distributor 160 from the ignitor 158, and gaseous mixture is lit by the spark and carries out explosion combustion of it by it.
[0043] Operation of this engine 150 is controlled by the electronic control unit (hereafter referred to as EFIECU) 170. The various sensors in which the operational status of an engine 150 is shown are connected to EFIECU170. For example, it is the rotational frequency sensor 176, the angle-of-rotation sensor 178, etc. which are prepared for the coolant temperature sensor 174 and distributor 160 which detect the water temperature of the throttle-valve position sensor 167 which detects the opening (position) of a throttle valve 166, the inlet-pipe negative pressure sensor 172 which detects the load of an engine 150, and an engine 150, and detect the rotational frequency and angle of rotation of a crankshaft 156. In addition, although the starting switch 179 which detects the condition ST of an ignition key was connected to EFIECU170 in addition to this, illustration of other sensors, a switch, etc. was omitted.
[0044] It is combined with planetary gear 120, the motor MG 1, and Motor MG 2 which are later mentioned through the damper 157 which controls the amplitude of the torsional oscillation produced in a crankshaft 156, and the crankshaft 156 of an engine 150 is combined with the differential gear 114 through the power transfer gear 111 which sets the axis of rotation as a driving shaft 112 further. Therefore, finally the power outputted from the power output unit 110 is transmitted to the driving wheel 116,118 on either side. It connects with the control unit 180 electrically, and drive control of a motor MG 1 and the motor MG 2 is carried out by this control unit 180. Although the configuration of a control unit 180 is explained in full detail later, the interior is equipped with Control CPU and accelerator pedal position-sensor 164a prepared in the shift position sensor 184 formed in the shift lever 182 or the accelerator pedal 164, brake-pedal position-sensor 165a prepared in the brake pedal 165 are connected. Moreover, the control unit 180 is exchanging various information by EFIECU170 and the communication link which were mentioned above. About control including the exchange of such information, it mentions later.
[0045] As shown in drawing 1 , the power output unit 110 of an example Greatly The damper 157 which connects the crankshaft 156 and the carrier shaft 127 of an engine 150 and an engine 150, and controls the amplitude of the torsional oscillation of a crankshaft 156, the planetary gear 120 by which the planetary carrier 124 was combined with the carrier shaft 127, It consists of control units 180 which carry out drive control of the motor MG 2 combined with the ring wheel 122 of the motor MG 1 combined with the sun gear 121 of planetary gear 120, and planetary gear 120, and the motors MG1 and MG2.
[0046] Drawing 2 explains the configuration of planetary gear 120 and motors MG1 and MG2. The sun gear 121 combined with the sun gear shaft 125 in the air with which planetary gear 120 penetrated the shaft center on the carrier shaft 127, The ring wheel 122 combined with the carrier shaft 127 and the ring wheel shaft 126 of the same axle, Two or more planetary pinion gears 123 which revolve around the sun while it is arranged between a sun gear 121 and a ring wheel 122 and the periphery of a sun gear 121 is rotated, It consists of planetary carriers 124 which are combined with the edge of the carrier shaft 127 and support the axis of rotation of each planetary pinion gear 123 to revolve. In these planetary gear 120, 3 of the sun gear shaft 125 combined with the sun gear 121, the ring wheel 122, and the planetary carrier 124, respectively, the ring wheel shaft 126, and the carrier shaft 127 shafts are used as the I/O shaft of power, and if the power outputted and inputted among three shafts to any 2 shafts is determined, the power outputted and inputted by one residual shaft will become settled based on the power outputted and inputted biaxial [which was determined]. The details about I/O of the power to three shafts of these planetary gear 120 are mentioned later. In addition, the resolver 139,149,159 which detects angle-of-rotation thetas, thetar, and thetac, respectively is formed in the sun gear shaft 125, the ring wheel shaft 126, and the carrier shaft 127.
[0047] The power fetch gear 128 for the ejection of power is combined with the ring wheel 122. This power fetch gear 128 is connected to the power transfer gear 111 by the chain belt 129, and transfer of power is made between the power fetch gear 128 and the power transfer gear 111.
[0048] A motor MG 1 is constituted as a synchronous motor generator, and is equipped with Rota 132 which has two or more permanent magnets 135 in a peripheral face, and the stator 133 around which the three phase coil 134 which forms rotating magnetic field was wound. Rota 132 is combined with the sun gear shaft 125 combined with the sun gear 121 of planetary gear 120. A stator 133 carries out the laminating of the sheet metal of a non-oriented magnetic steel sheet, is formed, and is being fixed to the case 119. This motor MG 1 operates as a motor which carries out the rotation drive

of Rota 132 by the interaction of the magnetic field by the permanent magnet 135, and the magnetic field formed with the three phase coil 134, and operates as a generator which makes the both ends of the three phase coil 134 produce electromotive force by the interaction of the magnetic field by the permanent magnet 135, and rotation of Rota 132.
[0049] A motor MG 2 is constituted as a synchronous motor generator like a motor MG 1, and is equipped with Rota 142 which has two or more permanent magnets 145 in a peripheral face, and the stator 143 around which the three phase coil 144 which forms rotating magnetic field was wound. Rota 142 is combined with the ring wheel shaft 126 combined with the ring wheel 122 of planetary gear 120, and the stator 143 is being fixed to the case 119. The stator 143 of a motor MG 2 also carries out the laminating of the sheet metal of a non-oriented magnetic steel sheet, and is formed. It operates as a motor or a generator like [this motor MG 2] a motor MG 1.
[0050] Next, the control unit 180 which carries out drive control of the motors MG1 and MG2 is explained. As shown in drawing 1 , the control unit 180 consists of batteries 194 which are the control CPU 190 and the rechargeable battery which control the 1st drive circuit 191 which drives a motor MG 1, the 2nd drive circuit 192 which drives a motor MG 2, and both the drive circuit 191,192. Control CPU 190 is one chip microprocessor, and equips the interior with RAM190a for works, ROM190b which memorized the processing program, input/output port (not shown) and EFIECU170, and the serial communication port (not shown) that performs a communication link. In this control CPU 190, angle-of-rotation thetas of the sun gear shaft 125 from a resolver 139, Angle-of-rotation thetar of the ring wheel shaft 126 from a resolver 149, angle-of-rotation thetac of the carrier shaft 127 from a resolver 159, The accelerator pedal position AP from accelerator pedal position-sensor 164a (the amount of treading in of an accelerator pedal) The brake-pedal position BP from brake-pedal position-sensor 165a (the amount of treading in of a brake pedal), The shift position SP from the shift position sensor 184 The remaining capacity of the current values Iu1 and Iv1 from two current detectors 195,196 prepared in the 1st drive circuit 191, the current values Iu2 and Iv2 from two current detectors 197,198 prepared in the 2nd drive circuit 192, and a battery 194 The remaining capacity BRM from the remaining capacity detector 199 to detect etc. is inputted through input port. In addition, what the remaining capacity detector 199 measures the specific gravity of the electrolytic solution of a battery 194 or the weight of the whole battery 194, and detects remaining capacity, the thing which calculates the current value and time amount of charge and discharge, and detects remaining capacity, the thing which detects remaining capacity by making between the terminals of a battery short-circuit momentarily, and measuring sink internal resistance for current are known.
[0051] Moreover, from control CPU 190, the control signal SW2 which drives six transistors Tr11 as the control signal SW1 which drives six transistors Tr1 which are the switching elements prepared in the 1st drive circuit 191 thru/or Tr6, and a switching element prepared in the 2nd drive circuit 192 thru/or Tr16 is outputted. Six transistors Tr1 in the 1st drive circuit 191 thru/or Tr6 constitute the transistor inverter, two pieces are arranged at a time in a pair, respectively so that it may become a source and sink side to power supply Rhine L1 and L2 of a pair, and each of the three phase coil (UVW) 34 of a motor MG 1 is connected at the node. Power supply Rhine L1 and L2 controls sequentially the rate of the transistor Tr1 which makes a pair by control CPU 190 since it connects with the plus [of a battery 194], and minus side, respectively thru/or the ON time amount of Tr6 with a control signal SW1, and if the current which flows in each coil of the three phase coil 134 is made into a false sine wave by PWM control, rotating magnetic field will be formed with the three phase coil 134.
[0052] On the other hand, six transistors Tr11 of the 2nd drive circuit 192 thru/or Tr16 also constitute the transistor inverter, is arranged, respectively, and the node of the transistor which makes a pair is connected to each of the three phase coil 144 of a motor MG 2. [as well as the 1st drive circuit 191] Therefore, the transistor Tr11 thru/or the ON time amount of Tr16 which makes a pair by control CPU 190 is sequentially controlled with a control signal SW2, and if the current which flows in each coil 144 is made into a false sine wave by PWM control, rotating magnetic field will be formed with the three phase coil 144.
[0053] Actuation of the power output unit 110 of the example which explained the configuration above is explained. In addition, by the following explanation, "power" is expressed with the gestalt of the product of the torque which acts on a shaft, and the rotational frequency of the shaft, and means the magnitude of the energy outputted to per unit time amount. On the other hand, a "power condition" shall show the operation point which becomes settled with the torque which gives a certain power, and the combination of a rotational frequency. Therefore, the "operation point" which gives a certain "power" will exist in an infinite number with torque and the combination of a rotational frequency. In addition, as the energy per unit time amount, i.e., "power" and the term of homonymy, the exchange of the energy in between [every] **, and since in other words it is controlled on the basis of the energy balance per unit time amount, the term "energy" uses a power output unit hereafter. Similarly, "power" and the "electrical energy" which mean the electrical energy per unit time amount are used as a term of homonymy.
[0054] The principle of operation of the power output unit 110 of an example, especially the principle of torque

conversion are as follows. When operating an engine 150 on the operation point P1 of a rotational frequency Ne and Torque Te and operating the ring wheel shaft 126 on the operation point P2 of a rotational frequency Nr which is different although it is the same energy as the energy Pe outputted from this engine 150, and Torque Tr, the case where carry out torque conversion and the power outputted from an engine 150 is made to act on the ring wheel shaft 126 is considered. The engine 150 at this time, the rotational frequency of the ring wheel shaft 126, and the relation of torque are shown in drawing 4 .

[0055] Three shafts of planetary gear 120 (according to the place which device study teaches, the relation between the rotational frequency in the sun gear shaft 125, the ring wheel shaft 126, and the carrier shaft 127 or torque can be expressed as drawing called collinear drawing illustrated to drawing 5 and drawing 6 , and solution Lycium chinense grows in it geometrically.) In addition, the rotational frequency of three shafts and the relation of torque to planetary gear 120 are also analyzable in formula by calculating the energy of each shaft etc., even if it does not use above-mentioned collinear drawing. By this example, since explanation is easy, it explains using collinear drawing.

[0056] The axis of ordinate in drawing 5 is a rotational frequency shaft of three shafts, and a horizontal axis expresses the ratio of the location of the axis of coordinates of three shafts. That is, when the axes of coordinates S and R of the sun gear shaft 125 and the ring wheel shaft 126 are taken to both ends, the axis of coordinates C of the carrier shaft 127 is defined as a shaft which divides Shaft S and Shaft R interiorly to 1:rho. rho is the ratio of the number of teeth of a sun gear 121 to the number of teeth of a ring wheel 122 here, and it is expressed with a degree type (1).

[0057]

[Equation 1]

$$\rho = \frac{\text{サンギヤの歯数}}{\text{リングギヤの歯数}} \quad \cdots (1)$$

[0058] The engine 150 is operated at the rotational frequency Ne, since the case where the ring wheel shaft 126 is operated at the rotational frequency Nr is considered, the rotational frequency Ne of an engine 150 can be now plotted on the axis of coordinates C of the carrier shaft 127 with which the crankshaft 156 of an engine 150 is combined, and a rotational frequency Nr can be plotted on the axis of coordinates R of the ring wheel shaft 126. If the straight line which passes along both this point is drawn, it can ask for the rotational frequency Ns of the sun gear shaft 125 as a rotational frequency expressed on the intersection of this straight line and axis of coordinates S. Hereafter, this straight line is called a collinear of operation. In addition, it can ask for a rotational frequency Ns by the proportion equation (degree type (2)) using a rotational frequency Ne and a rotational frequency Nr. Thus, in planetary gear 120, if it opts for any two rotations among a sun gear 121, a ring wheel 122, and the planetary carrier 124, it will opt for one residual rotation based on two rotations for which it opted.

[0059]

[Equation 2]

$$Ns = Nr - (Nr - Ne)\,\frac{1+\rho}{\rho} \quad \cdots (2)$$

[0060] Next, the torque Te of an engine 150 is made to act on the drawn collinear of operation upwards from drawing Nakashita by making the axis of coordinates C of the carrier shaft 127 into line of action. Since a collinear of operation can be dealt with as the rigid body at the time of making the force as a vector act to torque at this time, the torque Te made to act on an axis of coordinates C is separable into the torque Tes on an axis of coordinates S, and the torque Ter on an axis of coordinates R with the technique of separation of the force to two parallel different line of action. The magnitude of Torque Tes and Ter is expressed by the degree type (3) at this time.

[0061]

[Equation 3]

$$Tes = Te \times \frac{\rho}{1+\rho}$$

$$Ter = Te \times \frac{1}{1+\rho} \quad \cdots (3)$$

[0062] What is necessary is just to take balance of the force of a collinear of operation, in order for the collinear of operation to be stable in this condition. That is, magnitude is the same as Torque Tes, the torque Tm1 with the opposite sense is made to act, magnitude is the same to resultant force with torque and Torque Ter with the opposite sense on an axis of coordinates R in the same magnitude as the torque Tr outputted to the ring wheel shaft 126, and the sense makes

the opposite torque Tm2 act on an axis of coordinates S. This torque Tm1 can act by the motor MG 1, and torque Tm2 can be made to act by the motor MG 2. Since torque is made to act on a rotational direction and the rotational reverse sense by the motor MG 1 at this time, a motor MG 1 will operate as a generator and revives electrical energy Pm1 expressed with the product of torque Tm1 and a rotational frequency Ns from the sun gear shaft 125. By the motor MG 2, since the direction of torque is the same as the direction of rotational, a motor MG 2 operates as a motor and is outputted to the ring wheel shaft 126 by making into power electrical energy Pm2 expressed by the product of torque Tm2 and a rotational frequency Nr.

[0063] Here, if electrical energy Pm1 and electrical energy Pm2 are made equal, all the power consumed by the motor MG 2 can be revived by the motor MG 1, and it can be provided. What is necessary is for that just to make equal the thing which outputs all the inputted energy then the energy Pe outputted from an engine 150 since it is good, and energy Pr outputted to the ring wheel shaft 126. That is, the energy Pe expressed with the product of Torque Te and a rotational frequency Ne and energy Pr expressed with the product of Torque Tr and a rotational frequency Nr are made equal. If it compares with drawing 4 , torque conversion will be carried out and the power expressed with the torque Te outputted from the engine 150 currently operated on the operation point P1 and a rotational frequency Ne will be outputted to the ring wheel shaft 126 as power expressed with the same energy at Torque Tr and a rotational frequency Nr. As mentioned above, the power outputted to the ring wheel shaft 126 is transmitted to a driving shaft 112 by the power fetch gear 128 and the power transfer gear 111, and is transmitted to a driving wheel 116,118 through a differential gear 114. Therefore, since linear relation is materialized for the power outputted to the ring wheel shaft 126, and the power transmitted to a driving wheel 116,118, the power transmitted to a driving wheel 116,118 is controllable by controlling the power outputted to the ring wheel shaft 126.

[0064] Although the rotational frequency Ns of the sun gear shaft 125 is positive in collinear drawing shown in drawing 5 , as shown in collinear drawing shown in drawing 6 , it may become negative at the rotational frequency Ne of an engine 150, and the rotational frequency Nr of the ring wheel shaft 126. At this time, by the motor MG 1, since the direction of rotational and the direction where torque acts become the same, a motor MG 1 operates as a motor and consumes electrical energy Pm1 expressed by the product of torque Tm1 and a rotational frequency Ns. On the other hand, by the motor MG 2, since the direction of rotational and the direction where torque acts become reverse, a motor MG 2 will operate as a generator and will revive electrical energy Pm2 expressed by the product of torque Tm2 and a rotational frequency Nr from the ring wheel shaft 126. In this case, if electrical energy Pm1 consumed by the motor MG 1 and electrical energy Pm2 revived by the motor MG 2 are made equal, electrical energy Pm1 consumed by the motor MG 1 can be exactly provided by the motor MG 2.

[0065] As mentioned above, although the fundamental torque conversion in the power output unit 110 of an example was explained The power outputted from an engine 150 besides the actuation which the power output unit 110 of an example carries out torque conversion of all the power outputted from such an engine 150, and is outputted to the ring wheel shaft 126 (product of Torque Te and a rotational frequency Ne), By adjusting electrical energy Pm1 revived or consumed by the motor MG 1, and electrical energy Pm2 consumed or revived by the motor MG 2 It can consider as the actuation which finds out excessive electrical energy and charges a battery 194, or can also consider as various actuation, such as actuation with which the electrical energy running short is compensated with the power stored in the battery 194.

[0066] In addition, the above principle of operation explained the conversion efficiency of the power by planetary gear 120, a motor MG 1, a motor MG 2 and a transistor Tr1, or Tr16 as a value 1 (100%). Since it is less than one value in fact, it is necessary to consider as a bigger value a little than the energy Pr which outputs the energy Pe outputted from an engine 150 to the ring wheel shaft 126, or to make energy Pr outputted to the ring wheel shaft 126 at reverse into a value [a little] smaller than the energy Pe outputted from an engine 150. For example, what is necessary is just to consider as the value computed by multiplying by the inverse number of conversion efficiency by the energy Pr outputted to the ring wheel shaft 126 in the energy Pe outputted from an engine 150. Moreover, what is necessary is to consider as the value computed from what multiplied the power revived by the motor MG 1 in the state of collinear drawing of drawing 5 in the torque Tm2 of a motor MG 2 by the effectiveness of both motors, and just to compute the power consumed by the motor MG 1 in the state of collinear drawing of drawing 6 from what was broken by effectiveness of both motors. In addition, although energy is lost as heat by machine friction etc. in planetary gear 120, there are very few the amounts of losses, if it sees from the amount of whole, and the effectiveness of the synchronous motor used for motors MG1 and MG2 is very close to a value 1. Moreover, very small things, such as GTO, are known also for a transistor Tr1 thru/or the on resistance of Tr16. Therefore, since it becomes a thing near a value 1, and the following explanation is also easy for explanation, the conversion efficiency of power is dealt with as a value 1 (100%), unless it shows clearly.

[0067] Next, in the vehicles which are in a run state by such torque control, the shift control at the time of suspending operation of an engine 150 is explained based on the engine shutdown control routine illustrated to drawing 7 with a run state. This routine is performed, when there are directions of the switch to the operation mode by the motor MG 2 by the operator, or when the operation mode by the motor MG 2 is chosen by the operation mode judging processing which is performed by the control CPU 190 of a control unit 180 and which is not illustrated.

[0068] If an engine shutdown control routine is performed, the control CPU 190 of a control unit 180 will output the signal of engine shutdown to EFIECU170 by communication link first (step S100). EFIECU170 which received the shutdown signal of an engine 150 stops impression of the voltage to an ignition plug 162 while suspending the fuel injection from a fuel injection valve 151, and it makes a throttle valve 166 further a close by-pass bulb completely. Operation of an engine 150 stops by such processing.

[0069] Then, control CPU 190 performs processing which inputs the rotational frequency Ne of an engine 150 (step S102). It can ask for the rotational frequency Ne of an engine 150 from angle-of-rotation thetac of the carrier shaft 127 detected by the resolver 159 prepared in the carrier shaft 127 combined through the crankshaft 156 and the damper 157. In addition, direct detection of the rotational frequency Ne of an engine 150 can also be carried out also by the rotational frequency sensor 176 prepared for the distributor 160. In this case, control CPU 190 will receive the information on a rotational frequency Ne from EFIECU170 connected to the rotational frequency sensor 176 by communication link.

[0070] An input of the rotational frequency Ne of an engine 150 sets up the initial value of the time counter TC based on the inputted rotational frequency Ne (step S104). Here, an increment is carried out in case the repeat step S106 thru/or processing of S116 are performed, as the time counter TC is an argument used when setting up aim rotational frequency Ne* of an engine 150 at step S108 mentioned later and is shown in step S106. A setup of the initial value of this time counter TC is performed using the map at the time of setting up aim rotational frequency Ne* of an engine 150 by making the time counter TC into an argument, for example, the map shown in drawing 8 . As shown in drawing 8 , a setup of the time counter TC takes a rotational frequency Ne on an axis of ordinate (shaft of aim rotational frequency Ne*), and is performed by calculating the value of the time counter TC corresponding to this.

[0071] If the time counter TC is set up, the set-up time counter TC will be incremented (step S106), and aim rotational frequency Ne* of an engine 150 will be set up using the map shown in this time counter TC which incremented and drawing 8 (step S108). In a setup of aim rotational frequency Ne*, the time counter TC is taken on a horizontal axis (shaft of the time counter TC), and it is carried out by asking for aim rotational frequency Ne* corresponding to this. In addition, signs that it asked for aim rotational frequency Ne* as "TC+1" which applied the value 1 to the initial value of the time counter TC were displayed on drawing 8 . Then, the rotational frequency Ne of an engine 150 is inputted (step S110), and torque command value Tm1* of a motor MG 1 is set up by the degree type (4) using the inputted rotational frequency Ne and set-up aim rotational frequency Ne* (step S112). The 1st term of the right-hand side in a formula (4) is a proportional which negates the deflection from aim rotational frequency Ne* of a rotational frequency Ne here, and the 2nd term of the right-hand side is an integral term which abolishes steady-state deviation. In addition, K1 and K2 are proportionality constants.

[0072]

[Equation 4]

$$Tm1^* \leftarrow K1\,(Ne^* - Ne) + K2 \int (Ne^* - Ne)\,dt \quad \cdots (4)$$

[0073] Then, torque command value Tm2* of a motor MG 2 is set up by the degree type (5) using command value Tr* of torque and torque command value Tm1* of a motor MG 1 which should be outputted to the ring wheel shaft 126 (step S114). Where operation of an engine 150 is suspended, when the 2nd term of the right-hand side in a formula (5) outputs the torque of torque command value Tm1* from a motor MG 1, it is torque which acts on the ring wheel shaft 126 through planetary gear 120, and K3 is a proportionality constant. If K3 is in the condition of balance of the collinear of operation in collinear drawing, it is a value 1, but since it is a transient in the case of the shutdown of an engine 150 and the part of the torque outputted from a motor MG 1 is used for change of movement of the system of inertia which consists of an engine 150 and a motor MG 1, it becomes a value smaller than a value 1. What is necessary is to search for the torque (inertia torque) which multiplies the moment of inertia seen from the motor MG 1 of an above-mentioned system of inertia by the angular acceleration of the sun gear shaft 125, and is used for change of movement of a system of inertia, and just to break what subtracted this from torque command value Tm1* by gear ratio rho, in order to search for this torque correctly. In the example, since torque command value Tm1* set up by this routine was a comparatively small value, count was simplified using the proportionality constant K3. In addition, command value Tr* of the torque which should be outputted to the ring wheel shaft 126 is set up based on the demand torque configuration routine

illustrated to drawing 9 based on the amount of treading in of the accelerator pedal 164 by the operator. Hereafter, the processing which sets up this torque command value Tr* is explained briefly.
[0074]
[Equation 5]

$$Tm2 \leftarrow Tr* - K3 \times \frac{Tm1*}{\rho} \quad \cdots (5)$$

[0075] Repeat activation of the demand torque configuration routine of drawing 9 is carried out for every (for example, 8msec) predetermined time. If this routine is performed, the control CPU 190 of a control unit 180 will perform first processing which reads the rotational frequency Nr of the ring wheel shaft 126 (step S130). It can ask for the rotational frequency Nr of the ring wheel shaft 126 from angle-of-rotation thetar of the ring wheel shaft 126 detected by the resolver 149. Then, processing which inputs the accelerator pedal position AP detected by accelerator pedal position-sensor 164a is performed (step S132). Since an accelerator pedal 164 is broken in when it senses that an operator's output torque is insufficient, the accelerator pedal position AP corresponds to the torque which should be outputted to the ring wheel shaft 126, as a result a driving wheel 116,118. If the accelerator pedal position AP is read, processing which derives torque command value Tr* which is the desired value of the torque which should be outputted to the ring wheel shaft 126 based on the read accelerator pedal position AP and the rotational frequency Nr of the ring wheel shaft 126 will be performed (step S134). The torque which should be outputted to the ring wheel shaft 126 is derived without the ability being able to draw the torque which should be outputted to a driving wheel 116,118 here because the ring wheel shaft 126 will result in deriving the torque which should be outputted to a driving wheel 116,118, if the torque which should be outputted to the ring wheel shaft 126 is derived, since it is mechanically combined with the driving wheel 116,118 through the power fetch gear 128, the power transfer gear 111, and the differential gear 114. In addition, in the example, the value of torque command value Tr* shall be derived based on the map which memorized beforehand the map in which the relation between the rotational frequency Nr of the ring wheel shaft 126, and the accelerator pedal position AP and torque command value Tr* is shown to ROM190b, and was memorized to the read accelerator pedal position AP, the rotational frequency Nr of the ring wheel shaft 126, and ROM190b when the accelerator pedal position AP was read. An example of this map is shown in drawing 10 .
[0076] In this way, if torque command value Tm1* of a motor MG 1 is set up at step S112 and torque command value Tm2* of a motor MG 2 is set up at step S114 By the control routine of the motor MG 2 illustrated to the control routine and drawing 12 of the motor MG 1 illustrated to drawing 11 by which repeat activation is carried out for every (every [for example,] 4msec) predetermined time using interrupt processing A motor MG 1 and a motor MG 2 are controlled so that the torque of the set-up command value is outputted from a motor MG 1 and a motor MG 2. About control of such a motor MG 1 and control of a motor MG 2, it mentions later.
[0077] Next, the control CPU 190 of a control unit 180 compares the rotational frequency Ne and threshold Nref of an engine 150 (step S116). Here, a threshold Nref is set up as a value near the value set up as aim rotational frequency Ne* of an engine 150 in processing of the operation mode by the motor MG 2. In the example, since aim rotational frequency Ne* of the engine 150 in processing of the operation mode by the motor MG 2 is set as the value 0, the threshold Nref is set up as a value near the value 0. In addition, this value is a value smaller than the lower limit of the rotational frequency field where the system combined with the crankshaft 156 combined by the damper 157 and the carrier shaft 127 produces resonance phenomena. Therefore, when the rotational frequency Ne of an engine 150 is larger than a threshold Nref, it is still in the transient of the shutdown of an engine 150, it judges that it has not become under the lower limit of the rotational frequency field which produces resonance phenomena, and repeat activation of return, step S106, or the processing of S116 is carried out at step S106. If repeat activation of step S106 thru/or the processing of S116 is carried out, the increment of the time counter TC is carried out, and since aim rotational frequency Ne* of an engine 150 is set up as a smaller value based on the map shown in drawing 8 , the rotational frequency Ne of an engine 150 becomes small each time with the inclination of aim rotational frequency Ne* of the map shown in drawing 8 , and the same inclination. Therefore, beyond the inclination of a natural change of the rotational frequency Ne when the fuel injection to an engine 150 stops the inclination of aim rotational frequency Ne*, then the rotational frequency Ne of an engine 150 can be promptly made small, and the rotational frequency Ne of under the inclination of a natural change of a rotational frequency Ne, then an engine 150 can be gently made small. In the example, since it assumes passing through the rotational frequency field which produces above-mentioned resonance phenomena, the inclination of aim rotational frequency Ne* is set up beyond the inclination of a natural change of a rotational frequency Ne.
[0078] On the other hand, if the rotational frequency Ne of an engine 150 becomes below the threshold Nref, while setting the cancellation torque Tc as torque command value Tm1* of a motor MG 1 (step S118), torque command value

Tm2* of a motor MG 2 is set up by the top type (6) (step S120), and it waits to carry out predetermined time progress (step S122). Here, the cancellation torque Tc is the torque for preventing so-called undershooting [from which the rotational frequency Ne of an engine 150 serves as a negative value]. In addition, when suspending operation of an engine 150 positively by the motor MG 1 which receives PI control, it mentioned above about the reason which the rotational frequency Ne of an engine 150 undershoots.

[0079] If predetermined time progress is carried out where the cancellation torque Tc is outputted from a motor MG 1, while setting a value 0 as torque command value Tm1* of a motor MG 1 (step S124), torque command value Tr* is set as torque command value Tm2* of a motor MG 2 (step S126), and processing of the operation mode by the motor MG 2 which does not end and illustrate this routine is performed.

[0080] Next, control of a motor MG 1 is explained based on the control routine of the motor MG 1 illustrated to drawing 11 . If this routine is performed, the control CPU 190 of a control unit 180 will perform first processing which inputs angle-of-rotation thetas of the sun gear shaft 125 from a resolver 139 (step S180), and will perform processing which searches for the electrical angle theta 1 of a motor MG 1 from angle-of-rotation thetas of the sun gear shaft 125 (step S181). In the example, since the synchronous motor of four pole pairs is used as a motor MG 1, theta1=4thetas will be calculated. Then, processing which detects the current Iu1 and Iv1 which is flowing to U phase and V phase of the three phase coil 134 of a motor MG 1 with the current detector 195,196 is performed (step S182). Although current is flowing to the three phase of U, V, and W, since the total is zero, it is sufficient if the current which flows to two phases is measured. In this way, coordinate transformation (three phase -2 phase-number conversion) is performed using the current of the obtained three phase (step S184). Coordinate transformation is changing into the current value of d shaft of the synchronous motor of a permanent-magnet type, and q shaft, and is performed by calculating a degree type (6). Coordinate transformation is performed in the synchronous motor of a permanent-magnet type here because it is an amount with the current of d shaft and q shaft essential when controlling torque. It is also possible to control from the first with a three phase.

[0081]

[Equation 6]

$$\begin{bmatrix} Id1 \\ Iq1 \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta s-120) & \sin\theta s \\ -\cos(\theta s-120) & \cos\theta s \end{bmatrix} \begin{bmatrix} Iu1 \\ Iv1 \end{bmatrix} \quad \cdots (6)$$

[0082] Next, after changing into a biaxial current value, processing which asks for current command value Id1* of each shaft searched for from torque command value Tm1* in a motor MG 1, Iq1*, the current Id1 and Iq1 that actually flowed on each shaft, and deflection, and calculates the voltage command values Vd1 and Vq1 of each shaft is performed (step S186). That is, the following formulas (7) are calculated. Here, Kp1, Kp2, Ki1, and Ki2 are coefficients respectively. These coefficients are adjusted so that the property of the motor to apply may be suited. In addition, the voltage command values Vd1 and Vq1 are calculated from the portion (the 1st term of the formula (7) 1st type right-hand side) proportional to deflection **I with current command value I*, and an accumulated part (the 2nd term of this right-hand side) of the past of i batch of deflection **I.

[0083]

[Equation 7]

$$Vd1 = Kp1 \cdot \Delta Id1 + \Sigma Ki1 \cdot \Delta Id1$$

$$Vq1 = Kp2 \cdot \Delta Iq1 + \Sigma Ki2 \cdot \Delta Iq1 \quad \cdots (7)$$

[0084] Then, coordinate transformation (two phase -3 phase-number conversion) equivalent to the inverse transformation of the conversion which performed the voltage command value calculated in this way at step S184 is performed (step S188), and processing which asks for the voltage Vu1, Vv1, and Vw1 actually impressed to the three phase coil 134 is performed. It asks for each voltage by the degree type (8).

[0085]

[Equation 8]

$$\begin{bmatrix} Vu1 \\ Vv1 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta s & -\sin\theta s \\ \cos(\theta s-120) & -\sin(\theta s-120) \end{bmatrix} \begin{bmatrix} Vd1 \\ Vq1 \end{bmatrix}$$

$$Vw1 = -Vu1 - Vv1 \quad \cdots (8)$$

[0086] Since actual armature-voltage control is made by the transistor Tr1 of the 1st drive circuit 191 thru/or the on-off time amount of Tr6, it carries out PWM control of each transistor Tr1 thru/or the ON time amount of Tr6 so that it may become each voltage command value calculated by the formula (8) (step S199).

[0087] If the sense of the torque [in / for the sign of torque command value Tm1* of a motor MG 1 / collinear drawing of drawing 5 or drawing 6] Tm1 is made positive here Even if torque command value Tm1* of the same positive value is set up, when the sense on which torque command value Tm1* acts like the condition of collinear drawing of drawing 5 differs from the sense of rotation of the sun gear shaft 125, regenerative control is made, and power running control is made like the condition of collinear drawing of drawing 6 at the time of the same direction. However, since power running control of a motor MG 1 and regenerative control control the transistor Tr1 of the 1st drive circuit 191 thru/or Tr6 so that positive torque acts on the sun gear shaft 125 by the permanent magnet 135 attached in the peripheral face of Rota 132, and the rotating magnetic field produced according to the current which flows in the three phase coil 134 if torque command value Tm1* is positive, they turn into the same switching control. That is, if the sign of torque command value Tm1* is the same, even if control of a motor MG 1 is regenerative control and it is power running control, it will become the same switching control. Therefore, all of the regenerative control and power running control by the control routine of the motor MG 1 of drawing 11 can be performed. Moreover, since the direction of change of angle-of-rotation thetas of the sun gear shaft 125 read at step S180 only becomes reverse when torque command value Tm1* is negative, the control routine of the motor MG 1 of drawing 11 can also perform control at this time.

[0088] Next, control of a motor MG 2 is explained based on the control routine of the motor MG 2 illustrated to drawing 12 . Control processing of a motor MG 2 is replaced with torque command value Tm1* and angle-of-rotation thetas of the sun gear shaft 125 among control processings of a motor MG 1, and is completely the same as control processing of a motor MG 1 except for the point using torque command value Tm2* and angle-of-rotation thetar of the ring wheel shaft 126. Namely, while detecting angle-of-rotation thetar of the ring wheel shaft 126 using a resolver 149 (step S190) The electrical angle theta 2 of a motor MG 2 is computed from detected angle-of-rotation thetar (step S191). Then, each phase current of a motor MG 2 is detected using the current detector 197,198 (step S192). Then, the operation of coordinate transformation (step S194) and the voltage command values Vd2 and Vq2 is performed (step S196). Furthermore, backseat label conversion (step S198) of a voltage command value is performed, the transistor Tr11 of the 2nd drive circuit 192 of a motor MG 2 thru/or the on-off control time amount of Tr16 are found, and PWM control is performed (step S199).

[0089] Although power running control of the motor MG 2 is carried out by the sense of torque command value Tm2*, and the sense of rotation of the ring wheel shaft 126 here or regenerative control is carried out, both power running control and regenerative control can be performed by control processing of the motor MG 2 of drawing 12 like a motor MG 1. In addition, in the example, the sign of torque command value Tm2* of a motor MG 2 made positive the sense of the torque Tm2 at the time of the condition of collinear drawing of drawing 5 .

[0090] Next, the situation of change, such as the rotational frequency Ne of the engine 150 in the case of halt control of such an engine 150 and the torque Tm1 of a motor MG 1, is explained using explanatory drawing illustrated to collinear drawing illustrated to drawing 13 thru/or drawing 15 , and drawing 16 . Drawing 13 is collinear drawing when the engine shutdown control routine of drawing 7 begins and is performed, drawing 14 is collinear drawing when repeat activation of step S106 of an engine shutdown control routine thru/or the processing of S116 is carried out several times, and drawing 15 is collinear drawing when the rotational frequency Ne of an engine 150 becomes below the threshold Nref. In the example, since the inclination of aim rotational frequency Ne* in the map of drawing 8 is set up beyond the inclination of a natural change of a rotational frequency Ne, as shown in drawing 13 and drawing 14 , the torque Tm1 outputted from a motor MG 1 acts in the direction which makes the rotational frequency Ne of an engine 150 small compulsorily. Therefore, since the rotational frequency Ns of the sun gear shaft 125 serves as a negative value as it operates as a generator and is shown in drawing 14 after that, since torque Tm1 serves as a hand of cut of the sun gear shaft 125, and reverse sense when an engine shutdown control routine begins and is performed, a motor MG 1 will operate as a motor. Since the PI control of the motor MG 1 is carried out based on the rotational frequency Ne of an engine 150, and aim rotational frequency Ne* at this time, as it is shown in drawing 16 , the rotational frequency Ne of an engine 150 is late for aim rotational frequency Ne* a little, and it changes. In addition, since the rotational frequency Ns of the sun gear shaft 125 may serve as a negative value as explained using drawing 6 depending on the rotational frequency Ne of an engine 150 and the rotational frequency Nr of the ring wheel shaft 126 in the condition before directions of the shutdown of an engine 150 are outputted, collinear drawing of drawing 14 may turn into collinear drawing when an engine shutdown control routine begins and is performed. In this case, a motor MG 1 will operate as a motor from the start.

[0091] Since the fuel supply to an engine 150 stops in the state of such drawing 13 and collinear drawing of drawing

14 , there is no output of the torque from an engine 150. However, since the torque Tm1 which makes the rotational frequency Ne of an engine 150 small compulsorily from a motor MG 1 is outputted, the torque Tsc as the reaction will act on the carrier shaft 127. On the other hand, the torque Tsr outputted to the ring wheel shaft 126 through planetary gear 120 in connection with the torque Tm2 outputted from a motor MG 2 and the torque Tm1 outputted from a motor MG 1 acts on the ring wheel shaft 126. Although the torque Tsr which acts on this ring wheel shaft 126 can be searched for from change of movement of the system of inertia which consists of an engine 150 and a motor MG 1, and balance of a collinear of operation as mentioned above, it is comparable as the 2nd term of the right-hand side of a formula (5). Therefore, the torque of abbreviation torque command value Tr* will be outputted to the ring wheel shaft 126.
[0092] At step S116 of the engine shutdown control routine of drawing 7 , if the rotational frequency Ne of an engine 150 becomes below the threshold Nref, since the cancellation torque Tc is outputted from a motor MG 1, it will stop without carrying out undershoot shown in the dashed line of drawing 16 , and the rotational frequency Ne of an engine 150 will shift to processing of the operation mode by the motor MG 2 smoothly. In the example, torque command value Tm1* of a motor MG 1 is made into the value 0 at the time of the operation mode by this motor MG 2. For this reason, a collinear of operation settles in the smallest condition of the sum of energy required for making energy and Motor MG 1 required for making an engine 150 idle idle. In the example, the energy which friction, compression, etc. of energy required for making an engine 150 idle since the engine 150 uses the gasoline engine, i.e., the piston of an engine 150, take becomes larger than energy required for making Rota 132 of a motor MG 1 idle. Therefore, an engine 150 stops and a collinear of operation will be in the condition that a motor MG 1 idles, as shown in collinear drawing of drawing 15 . In addition, in collinear drawing of drawing 15 , the cancellation torque Tc outputted from a motor MG 1 was indicated.
[0093] According to the power output unit 110 of an example explained above, after there are directions of the shutdown of an engine 150, the rotational frequency Ne of an engine 150 can be quickly made into a value 0. Therefore, the rotational frequency of the field which produces the resonance phenomena of the torsional oscillation which made the engine 150 and the motor MG 1 the inertia mass can be passed quickly. Consequently, the damper 157 which controls the amplitude of torsional oscillation can be made into the thing of a simple configuration.
[0094] Moreover, according to the power output unit 110 of an example, since the cancellation torque Tc of the direction which the rotational frequency Ne of an engine 150 increases just before the rotational frequency Ne of an engine 150 becomes a value 0 is outputted from a motor MG 1, the undershoot of the rotational frequency Ne of an engine 150 can be controlled. Consequently, generating of vibration which may be produced by undershoot, an allophone, etc. can be prevented.
[0095] Although it was made for the inclination of aim rotational frequency Ne* to output the torque Tm1 which makes the rotational frequency Ne of an engine 150 small compulsorily from a motor MG 1 in the power output unit 110 of an example using a bigger map (map of drawing 8) than a natural change of the rotational frequency Ne of an engine 150 It replaces with the map of drawing 8 and you may make it the rotational frequency Ne of an engine 150 change gently using a map with the inclination of aim rotational frequency Ne* smaller than a natural change of the rotational frequency Ne of an engine 150. If it carries out like this, the rotational frequency Ne of an engine 150 can be changed gently.
[0096] Moreover, you may make it the rotational frequency Ne of an engine 150 change automatically using the map on which it replaces with the map of drawing 8 , and the inclination of aim rotational frequency Ne* becomes the same as a natural change of the rotational frequency Ne of an engine 150. In this case, what is necessary is just to set a value 0 as torque command value Tm1* of a motor MG 1, while suspending operation of an engine 150. The engine shutdown control routine in this case is illustrated to drawing 17 . By this routine, while setting a value 0 as torque command value Tm1* of a motor MG 1 (step S202), torque command value Tr* is set as torque command value Tm2* of a motor MG 2 (step S210). For this reason, torque will change from the motor MG 1 towards the smallest condition (condition of collinear drawing of drawing 15) of the sum of energy required for making energy and Motor MG 1 required for making an engine 150 idle idle in any way, consuming the kinetic energy of an engine 150 or a motor MG 1 by friction, compression, etc. of the piston of an engine 150, since it will not be outputted. Thus, since power is not consumed by the thing which does not output torque at all from a motor MG 1, then the motor MG 1, the energy efficiency of the whole equipment can be raised. In addition, the engine shutdown control routine of drawing 17 can serve as processing of the operation mode by the motor MG 2 as it is.
[0097] Although aim rotational frequency Ne* of the engine 150 in the operation mode by the motor MG 2 was made into the value 0, and the threshold Nref was made into the value 0 or the value of that near in the power output unit 110 of an example so that it might become this value, aim rotational frequency Ne* of the engine 150 in the operation mode by the motor MG 2 is made into values other than value 0, and it is good also considering a threshold Nref as that value

or a value of that near. For example, it is the case where make aim rotational frequency Ne* of an engine 150 into the value of idle rpm, and a threshold Nref is made into the value near idle rpm or the idle rpm etc.

[0098] Although control of the rotational frequency Ne of the engine 150 at the time of suspending operation of an engine 150 was explained with the power output unit 110 of an example while vehicles were running (i.e., when it is in the condition which the ring wheel shaft 126 is rotating) When vehicles have stopped (i.e., when it is in the condition which the ring wheel shaft 126 is not rotating), you may apply to control of the rotational frequency Ne of the engine 150 at the time of suspending operation of an engine 150.

[0099] Although setting processing of torque command value Tm1* of a motor MG 1 and setting processing of torque command value Tm2* of a motor MG 2 were carried out as processing of an engine shutdown control routine in the power output unit 110 of an example It is good also as what performs setting processing of torque command value Tm1* of a motor MG 1 as one of the processings of control of a motor MG 1, and performs setting processing of torque command value Tm2* of a motor MG 2 as one of the processings of control of a motor MG 2.

[0100] Although the power outputted to the ring wheel shaft 126 was taken out from between a motor MG 1 and motors MG 2 through the power fetch gear 128 combined with the ring wheel 122 in the power output unit 110 of an example, as shown in power output unit 110A of the modification of drawing 18 , it is good also as what extends and picks out ring wheel shaft 126 from a case 119. Moreover, as shown in power output unit 110B of the modification of drawing 19 , you may arrange so that it may become the order of planetary gear 120, a motor MG 2, and a motor MG 1 from an engine 150 side. In this case, sun gear shaft 125B may not be hollow, and ring wheel shaft 126B needs to be taken as a hollow shaft. If it carries out like this, the power outputted to ring wheel shaft 126B can be taken out from between an engine 150 and motors MG 2.

[0101] Next, the 2nd example of this invention is explained. Although the 2nd operation is equipped with the hardware configuration of the 1st example and abbreviation identitas, as shown in drawing 20 , it differs compared with the 1st example at the point which equips an engine 150 with the closing motion timing modification device 153. Moreover, the contents of the processing which a control unit 180 performs also differ. First, a difference of a hardware configuration is explained with reference to drawing 20 .

[0102] The closing motion timing modification device 153 adjusts the closing motion timing of inlet-valve 150a of an engine 150, and shows the detailed configuration to drawing 21 . Usually, opening and closing intake valve 150a by the cam attached in the inhalation-of-air cam shaft 240, exhaust air bulb 150b has become the device opened and closed by the cam attached in the exhaust air cam shaft 244. The exhaust air cam-shaft timing gear 246 combined with the inhalation-of-air cam-shaft timing gear 242 combined with the appearance which intake valve 150a and exhaust air bulb 150b can open and close to the timing according to the rotational frequency of an engine 150, and the inhalation-of-air cam shaft 240, and the exhaust air cam shaft 244 is connected with the crankshaft 156 by the timing belt 248. In addition to such a usual configuration, the inhalation-of-air cam-shaft timing gear 242 and the inhalation-of-air cam shaft 240 are combined through the VVT pulley 250 which operates with oil pressure, and OCV254 which is the control bulb of input oil pressure is formed in the VVT pulley 250 at the closing motion timing modification device 153. The interior of the VVT pulley 250 is constituted from combination of the movable movable piston 252 by shaft orientations with this oil pressure. In addition, the oil pressure inputted into the VVT pulley 250 is supplied by the engine oil pump 256.

[0103] The working principle of this closing motion timing modification device 153 is as follows. EFIECU170 determines the closing motion timing of a bulb according to the operation condition of an engine 150, and outputs the control signal which controls closing motion of OCV254. Consequently, the oil pressure inputted into the VVT pulley 250 changes, and the adjustable piston 252 moves to shaft orientations. Since the slot is minced in the direction of slant to the shaft at the adjustable piston 252, rotation of the adjustable piston 252 is also produced with migration to the above-mentioned shaft orientations, and whenever [setting-angle / of the inhalation-of-air cam shaft 240 combined with the adjustable piston 252 and the inhalation-of-air cam-shaft timing gear 242] is changed. In this way, the closing motion timing of intake valve 150a can be changed, and bulb overlap can be changed. In addition, the above-mentioned VVT pulley 250 is formed only in the inhalation-of-air cam-shaft 240 side, and since it has not prepared in the exhaust air cam shaft 244, bulb overlap is controlled by this example by controlling the closing motion timing of an intake valve.

[0104] Next, control of the control unit 180 in the 2nd example is explained. Drawing 22 is a flow chart which shows the engine shutdown tense manipulation routine in the 2nd example. This engine shutdown tense manipulation routine is performed by interruption processing every 8msec, after decision that it sees from the power calculated in an engine 150 from the run state of a vehicle, the remaining capacity SOC of a battery 194, etc. and an engine 150 is suspended is made and the fuel injection to delivery and an engine 150 suspends a command to that effect to EFIECU170. Starting of

this routine first performs processing (step S300) which sets the current aim torque STG of a motor MG 1 as Variable STGold, processing (step S305) which sets up the reduction torque STGmn, and processing (step S310) which anneals and sets up the processing time mntg of processing. Here, the reduction torque STGmn is the value beforehand set up corresponding to the rotational frequency Nr of the ring wheel shaft 126, i.e., the vehicle speed, as illustrated to drawing 23 . In the example, the relation shown in drawing 23 is beforehand memorized in ROM190b, and the reduction torque STGmn is set up according to the rotational frequency Nr of the ring wheel shaft 126. The reduction torque STGmn is torque which a motor MG 1 adds to the carrier shaft 127, as a result a crankshaft 156 positively, in order to reduce the rotational frequency of the engine 150 by which fuel injection was suspended. Moreover, it anneals and the processing time mntg of processing is time amount which sets up the rate of the relaxation in the processing eased in order to prevent generating of a torque shock from the value which was able to ask for the rate of reducing a rotational frequency, on the operation in the rotational frequency reduction processing in the open loop control mentioned later. This is set as a small value according to the rotational frequency Nr of the ring wheel shaft 126 so that it may illustrate to drawing 24 . The direction which eased the rate of annealing the rotational frequency Nr of the ring wheel shaft 126, so that the vehicle speed is small, since the vehicle speed is supported, and it making the processing time mntg of processing a big value, and reducing a torque command value is because generating of a torque shock can be prevented. The treatment of the processing time mntg is explained in an open loop control (step S350).

[0105] After performing many of these control settings next, it judges whether conditions 1 are satisfied (step S320). In conditions 1, it is decision whether the conditions which can shift to control were ready at the time of an engine shutdown, and in the example, after a halt of the fuel injection to an engine 150 is directed, it is the conditional judgment whether 300msec(s) passed. Since the output torque of an engine 150 does not necessarily decline immediately even if a halt of fuel injection is directed, it waits for progress of 300msec until the output torque by the side of waiting and an engine 150 is lost certainly. In addition, in response to directions of EFIECU170, following on a fuel cut, an engine 150 controls the closing motion timing modification device 153, and sets the closing motion timing of a bulb to the maximum lag side in the meantime. In addition, the closing motion timing modification device 153 is set to the maximum lag side for making the shock at the time of reducing the load at the time of next starting an engine 150, and carrying out motoring of the engine 150 as small as possible. If conditions 1 are not ready, it passes till then, the PID control based on the deflection of the real rotational frequency of an engine 150 and an aim rotational frequency is continued, and the rotational frequency of an engine 150 is held (step S330).

[0106] On the other hand, conditions 1 are satisfied, and at the time of a halt of an engine, when it is judged to control that it is good next, it is judged to be close to it whether the rotational frequency Ne of an engine 150 is beyond the predetermined value Nkn (step S340). The predetermined value Nkn used for this decision was under 200rpm and transit, if it was brake off, it was under 250rpm and transit, and when the rotational frequency Ne of an engine 150 has fallen by having performed control at the time of a halt of an engine, it is the conditions which suspend the open loop control mentioned later, and if it is brake-on, it is defined like 350rpm in the stop by this example. It was experimentally determined as a controllable rotational frequency that undershoot did not generate these rotational frequencies in the rotational frequency of an engine 150 in actual control.

[0107] When it is judged that an engine speed Ne is larger than the predetermined value Nkn, processing which reduces an engine speed by the open loop control next is performed (step S350). This processing is explained in detail later using drawing 25 . Here, priority is given to the whole engine shutdown tense understanding, and explanation of the engine shutdown tense manipulation routine of drawing 22 is continued. By performing reduction processing of the engine speed by the open loop control, the rotational frequency Ne of an engine 150 falls gradually. If the rotational frequency Ne of an engine 150 falls and it is less than the predetermined value Nkn, it will judge whether next the current aim torque STG is about 0 (step S360). If the aim torque STG does not serve as a value 0 mostly, processing (step S370) for preventing that the rotational frequency of an engine 150 undershoots is performed.

[0108] Guard processing (step S380) of a bound is performed, processing (step S390) which sets up the aim torque ttg on the control which calculated by the above-mentioned processing and performed guard processing after that as new aim torque STG is performed, and after [any / these] processing (steps S330, S350-S370) ends this routine. Guard processing of a bound is processing which restricts this to less than rating or the range of possible torque, when it had shifted from rating of a motor MG 1, or the calculated aim torque ttg sees from the remaining capacity of a battery 194 and has exceeded possible torque.

[0109] By carrying out repeat activation of the processing explained above, the rotational frequency of an engine 150 is controlled as follows roughly. First, if control which holds an engine speed to an aim rotational frequency by the usual PID control is performed (steps S320 and S330) and 300msec passes after the fuel supply to an engine 150 is suspended until 300msec(s) pass, it will change to an open loop control, torque will be added to the crankshaft 156 grade which is

the output shaft of an engine 150 from a motor MG 1 to hard flow with a hand of cut, and the rotational frequency of an engine 150 will be reduced in the range of predetermined deceleration. This situation was shown at the section A of drawing 27 . If the rotational frequency Ne of an engine 150 falls to the predetermined value Nkn, an open loop control will be ended and then undershoot prevention processing will be performed (steps S320, S340, S360, and S370). Here, the magnitude of aim torque is reduced and approaches a value 0 gradually. This situation was shown at the drawing 27 section B.

[0110] Next, the details of the open loop control of step S350 are explained using drawing 25 . Starting of an open loop control manipulation routine judges under a stop of a vehicle and transit first (step S351). If it is judged that a vehicle is running, it will process by annealing using the aim torque STGold in the control initiation time set up by control at the time of an engine shutdown, and the reduction torque STGmn, and processing which searches for the temporary aim torque ttg will be performed (step S352). It anneals in this case and the processing time nmtg beforehand set up according to the vehicle speed is used for time amount (refer to the drawing 22 step S310 and drawing 24). Although it anneals and processing is integral processing mathematically, when the processing performed at a predetermined interval realizes like this example, it realizes by taking a weighting average to the current value and desired value in many cases. In this example, for every processing time nmtg, weighting average processing is performed and the weighting coefficient given to the current value in that case is made about [of the weighting coefficient about desired value] into 1/16. When the processing which suspends an engine 150 by the open loop control is started Saying that it processes by annealing since the aim torque STG is held by the PID control (drawing 22 step S330) till then at the predetermined value The aim torque immediately after starting control at the time of an engine shutdown is reduced suddenly, and it is not made Torque STGmn, but toward the reduction torque STGmn set up based on drawing 23 , the value of the temporary aim torque ttg will be set up gradually, and it will go. By annealing, so gently [since it is set as such a big value that the vehicle speed is low] that the vehicle speed is low, the temporary aim torque ttg will approach the reduction torque STGmn, and the processing time nmtg of processing will go.

[0111] On the other hand, since it is not necessary to anneal with (step S351) and the vehicle speed, and to set up the time amount of processing when it is judged that a vehicle is stopping, the processing time is made into a fixed value (this example 128msec(s)), and it processes by annealing similarly (step S353). However, it replaces with the reduction torque STGmn defined according to the vehicle speed, and at the point using the value which applied the study value stgkg of aim torque to fixed reduction torque, it anneals under transit and is different from processing (step S352) with this processing under stop. At step S353, it is processing by annealing between the current aim torque STGold and (-14+stgkg)-STGold. In under transit, the torque shock resulting from engine 150 halt under stop is easy to be felt to not worrying the torque shock at the time of engine 150 halt so much. Then, the action of reduction of the aim torque under stop is learned, and it enables it to suspend an engine 150 without undershoot as much as possible. About the method of study of the study value stgkg, it mentions later.

[0112] If this processing is repeatedly performed at a predetermined interval, by the looseness which anneals and becomes settled by the processing time of processing, the temporary aim torque ttg will approach the reduction torque STGmn, and will go. If the temporary aim torque ttg is in agreement with the reduction torque STGmn, the torque which a motor MG 1 outputs will become almost fixed after that.

[0113] After processing by annealing under above transit and annealing under processing or stop, it judges whether conditions 2 are satisfied in the degree (step S354). Decision whether as for decision of conditions 2, all the following conditions are satisfied is said.

** The rotational frequency Ne of an engine 150 is 400 or less rpm, is ** stopping, and has not updated ** study value stgkg yet (Xstg!=1).

If at least one of the above three conditions is not materialized, nothing is performed, but it escapes to "NEXT", and this routine is once ended. On the other hand, if it will be in the condition that all of these three conditions are materialized, processing which calculates rotation decelerating **N will be performed (step S355).

[0114] Rotation decelerating **N is defined as deflection of a current rotational frequency from the rotational frequency when detecting a rotational frequency last time. In this example, the detection of a rotational frequency Ne itself is performed every 16msec(s). This rotation decelerating **N judges next whether close is in the range of a value -54 to the value -44 (step S356). If close is within the limits of this, rotation decelerating **N will perform nothing, but will fall out to NeXT, and will once end this routine. On the other hand, when it is judged that rotation decelerating **N is larger than a value -44, processing to which only a value 1 decreases the temporary study value tstg is performed (step S357), and when rotation decelerating **N is smaller than a value -54, processing for which only a value 1 increases the temporary study value tstg is performed (step S358). That is, the degree of moderation of the engine speed Ne in the drawing 27 section A is checked, and in order to make it reflected in the study value stgkg at the time of determining the

reduction torque under stop in control at the time of a next engine shutdown, the temporary study value tstg is fluctuated. The absolute value of the numeric value ({(-14+stgkg) -STGold} in step S353) which will hit the desired value of reduction torque if the rate of moderation is small is enlarged (a sign is -), and the absolute value is made small if the rate of moderation is large. Consequently, the rate of a fall of the rotational frequency Ne of the engine 150 at the time of an engine shutdown is adjusted in a proper range (from -54Nm / 16msec to -44Nm / 16msec) by learning control.

[0115] In addition, the temporary study value tstg performs guard processing so that it may enter within the bound value defined beforehand, and processing which sets a value 1 to the flag Xstg which shows that it learned is performed further (step S359). In addition, since repeat activation of this routine is carried out, the temporary study value tstg has been set up for annealing under activation and not changing the study value (step S353) in processing each time, without setting up the study value stgkg directly here. The learned study value stgkg will be used for the first time at the time of activation of control at the time of a next engine shutdown.

[0116] The open loop control manipulation routine explained above is performed, after the fuel supply to an engine 150 is suspended and 300msec(s) pass, towards the final torque value which becomes settled in a stop and transit, increases gradually the magnitude of the torque (torque with which the sign of torque joins hard flow with the hand of cut of minus, i.e., an output shaft) added to the output shaft of an engine 150 from a motor MG 1, and goes. If the vehicle has stopped when the rotational frequency Ne of an engine 150 gradually decreases (drawing 27 section A) and a rotational frequency is set to 400 or less rpm, based on the magnitude of rotation decelerating **N in the meantime, the study value tstg will be learned and it will go.

[0117] If the rotational frequency Ne of an engine 150 gradually decreases and it becomes smaller than the predetermined value Nkn soon, it will replace with the open loop control processing mentioned above, and undershoot prevention processing (drawing 22 step S370) will be performed. This undershoot prevention processing is explained referring to drawing 26 . When an undershoot prevention manipulation routine is started, it is degree type ttg=STGold +2 [Nm] first.

It is alike, and it follows and processing which searches for the temporary aim torque ttg is performed (step S371). Next, if the temporary aim torque ttg searched for judges that it is -two or less value (step S372) and becomes ttg>-2, processing which sets the temporary aim torque ttg as a value -2 will be performed (step S373). That is, the value -2 is guarded for the temporary aim torque ttg as a maximum by processing of steps S372 and S373.

[0118] By performing this processing, the magnitude of the torque which was acting so that the rotational frequency Ne of the output shaft of an engine 150 might be reduced till then is the range which does not exceed -2 [Nm], and is made small one by one. The magnitude of the torque which was being committed in the direction which slows down the output shaft of an engine 150 by this processing that changes the temporary aim torque ttg according to a top type, and goes is reduced by 2 [Nm] every every 8msec(s) which are the interval of interruption processing, approaches a value 0 gradually and goes (refer to drawing 27 section B).

[0119] It judges whether the rotational frequency Ne of an engine 150 is less than 40 rpm after processing of the above-mentioned step S372 or step S373 (step S374). If the rotational frequency Ne of an engine 150 is less than 40 rpm, it will judge that it is not necessary to apply the torque of the braking direction to the output shaft of an engine 150 any longer, and processing which sets a value 0 as the temporary aim torque ttg will be performed (step S375).

[0120] Then, it judges whether conditions 3 are satisfied (step S376). ** vehicle is stopping and it is study of ** study value in the condition that conditions 3 are satisfied (Xstg=1).

A case is said. If the above-mentioned conditions 3 are not satisfied, it escapes to "NEXT" and this routine is once ended. On the other hand, if the above-mentioned conditions 3 are satisfied, processing (step S377) which sets up the temporary study value tstg as a study value STGkg, and processing (step S378) which resets the learned flag Xstg to a value 0 will be performed. This routine is ended after these processings.

[0121] Consequently, if it decreases towards a value -2 and a rotational frequency Ne is set to less than 40 rpm as shown at the drawing 27 section B, let magnitude of the torque which will be added to the output shaft of an engine 150 if this undershoot prevention processing is performed be a value 0. Consequently, the rotational frequency Ne of an engine 150 does not produce the phenomenon (undershoot) which is less than a value 0.

[0122] While the demand which should get twisted in the 2nd example explained above, and should continue operation of ** and the (1) engine 150 exists, the rotational frequency Ne of an engine 150 is maintainable to an aim rotational frequency with PID control.

(2) When the demand which should continue operation of an engine 150 is lost, after it suspends the fuel supply to an engine 150 by EFIECU170 and 300msec passes, add the torque of the reverse sense to the carrier shaft 127 combined with the crankshaft 156 which is the output shaft of an engine 150 by the open loop control with a hand of cut by the

motor MG 1. Under the present circumstances, based on deflection with the aim rotational frequency (0) of the rotational frequency Ne of an engine 150, feedback control of the aim torque of a motor MG 1 is not carried out, but the algorithm defined beforehand determines aim torque. In the above-mentioned example, as shown in drawing 27 , it is determined that the magnitude of aim torque increases gradually and goes by the predetermined rate. By performing this control, at the time of a halt of an engine 150, rapidly big torque starts hard flow, a torque shock arises, and drivability is not worsened with the hand of cut. Moreover, since the torque of a hand of cut and an opposite direction is annealed and the torque of predetermined magnitude continues being added after termination of processing as shown in drawing 27 , reaction force torque also becomes fixed and drivability improves further.
[0123] (3) By adding torque towards a rotational frequency and reverse by the motor MG 1, the rotational frequency of the output shaft of an engine 150 falls and goes with predetermined deceleration (this example about -50rpm/16msec). Since this deceleration is set as the range which twists to an output shaft and resonance does not produce, it does not produce torsion resonance on the crankshaft 156 and the carrier shaft 127 which were combined through the damper 157.
[0124] (4) If a vehicle is stopping when the rotational frequency of an engine 150 is less than a predetermined rotational frequency (this example 400rpm), study will be performed from a decelerating condition so that the deceleration in control may go into a predetermined range at the time of a next engine shutdown.
[0125] (5) If the rotational frequency Ne of an engine 150 furthermore falls and it becomes below the predetermined value Nkn (an example 200rpm thru/or 350rpm), the magnitude of the torque added by the motor MG 1 will be shortly turned and dwindled to a value 0 at a predetermined rate, and the rotational frequency Ne of the output shaft of an engine 150 will control for zero or less value 156, i.e., a crankshaft, not to rotate reversely. It is designed by the premise referred to as not rotating reversely a crankshaft 156 in many cases, for example, the phenomenon called tooth-lead-angle lock with a crankshaft 156 rotating reversely can occur by the closing motion timing modification device 153. In this example, if the rotational frequency of an engine 150 falls, and magnitude of the torque added to an engine output shaft is made small and also it is less than 40rpm, addition torque would be made into the value 0 and the inverse rotation of a crankshaft 156 will be prevented certainly.
[0126] (6) The predetermined value Nkn used as the decision criterion at the time of performing this control will be under 200rpm and transit, if a vehicle is stopping, if its brake is off, it is under 250rpm and transit, and if a brake is ON, it is set as 350rpm. Therefore, the force in which it is added in the direction which reduces a rotational frequency to the output shaft of an engine 150 cannot be depended on the run state of a vehicle, but can be made regularity in general, and in spite of being an open loop control, the rotational frequency of an engine 150 can be smoothly turned and controlled to a value 0.
[0127] Although it shall apply to the vehicles of a two-flower drive of FR mold or FF mold in the power output unit 110 of the 1st and 2nd example, and its modification, as shown in power output unit 110C of the modification of drawing 28 , it is good also as what is applied to the vehicles of a four-flower drive. With this configuration, the motor MG 2 combined with the ring wheel shaft 126 is separated from the ring wheel shaft 126, it arranges independently in the rear wheel section of vehicles, and the driving wheel 117,119 of the rear wheel section is driven by this motor MG 2. On the other hand, it is combined with a differential gear 114 through the power fetch gear 128 and the power transfer gear 111, and the ring wheel shaft 126 drives the driving wheel 116,118 of the front-wheel section. It is possible to perform drawing 7 mentioned above under such a configuration or the engine shutdown control routine of drawing 22 .
[0128] In the power output unit 110 of an example, although PM form (permanent magnet form-ermanent Magnet type) synchronous motor was used for the motor MG 1 and the motor MG 2, if the both sides of regeneration actuation and a powering movement are possible, VR form (adjustable reluctance form; Variable Reluctance type) synchronous motor, a vernier motor, a direct current motor, an induction motor, a superconducting motor, a step motor, etc. can also be used.

[0129] Moreover, in the power output unit 110 of an example, although the transistor inverter was used as 1st and 2nd drive circuits 191,192, an IGBT (insulated-gate bipolar mode transistor; Insulated Gate Bipolar mode Transistor) inverter, a thyristor inverter, a voltage PWM (Pulse-Density-Modulation-ulseWidth Modulation) inverter, a square wave inverter (a voltage form inverter, current form inverter), a resonance inverter, etc. can also be used.
[0130] Furthermore, as a battery 194, although Pb battery, a NiMH battery, Li battery, etc. can be used, it can replace with a battery 194 and a capacitor can also be used.
[0131] In the power output unit 110 of an example, the crankshaft 156 of an engine 150 is connected to a motor MG 1 through a damper 157 and planetary gear 120. Although change of the rotational frequency Ne of an engine 150 was adjusted by outputting torque through planetary gear 120 from a motor MG 1 when operation of an engine 150 was suspended Direct continuation of the crankshaft CS of Engine EG is carried out to the axis of rotation RS of Motor MG

through Damper DNP like. the power output unit 310 of the modification illustrated to drawing 29 -- It is good also as what adjusts change of the rotational frequency Ne of the engine EG in the case of the shutdown of Engine EG by Motor MG. The effect as the effect that the power output unit 110 of an example does so that such a configuration is also the same can be done so. Moreover, in the above-mentioned example, although it has arranged so that it may become the same axle to the shaft which all exchanges power, motors MG1 and MG2 are easy for joining together through a gear, and should just define the arrangement to the shaft which exchanges power based on the demand on layout.

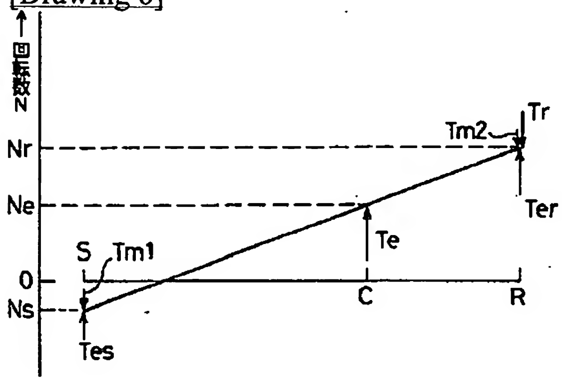
[0132] As mentioned above, although the gestalt of operation of this invention was explained, as for this invention, it is needless to say that it can carry out with the gestalt which is not limited to the gestalt of such operation at all, and becomes various within limits which do not deviate from the power output unit of an example from the summary of this inventions, such as means of transportation, modes carried in various industrial machines etc. in addition to this, such as a vessel and an aircraft.

[Translation done.]

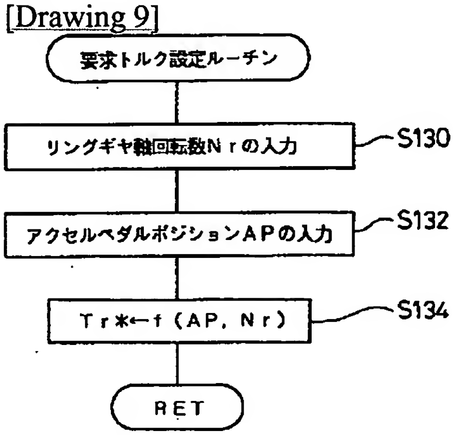
* NOTICES *

DRAWINGS

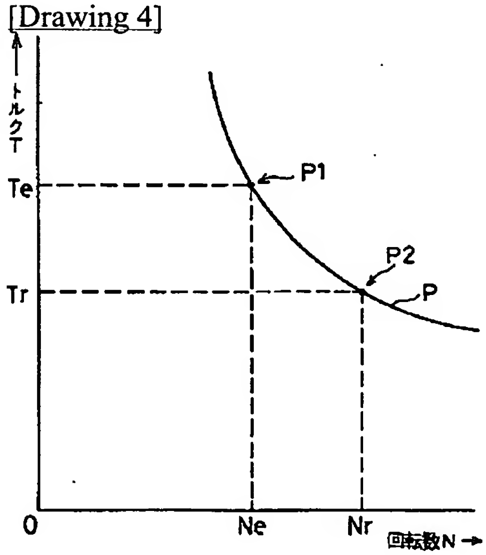
[Drawing 6]



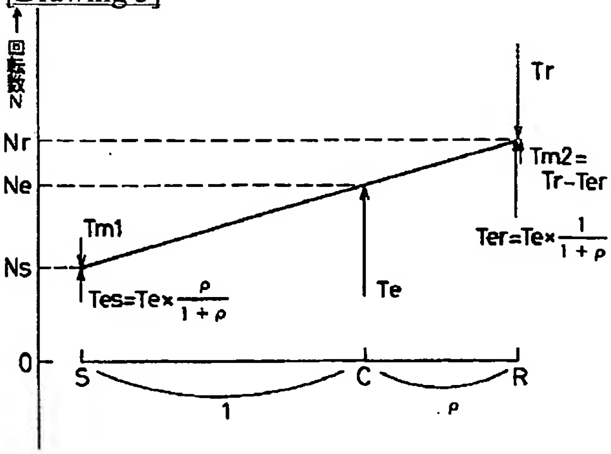
[Drawing 9]



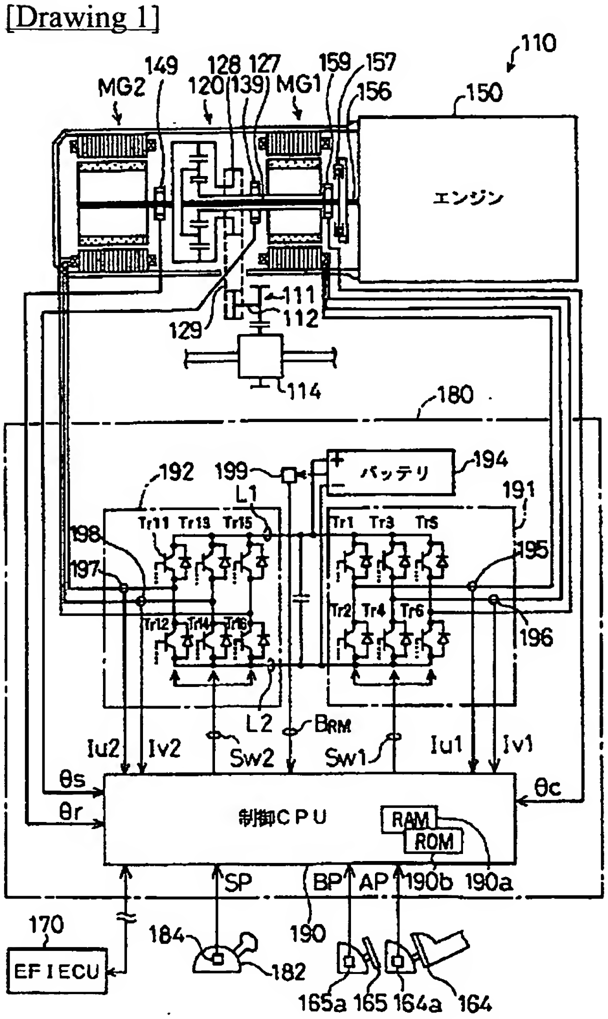
[Drawing 4]



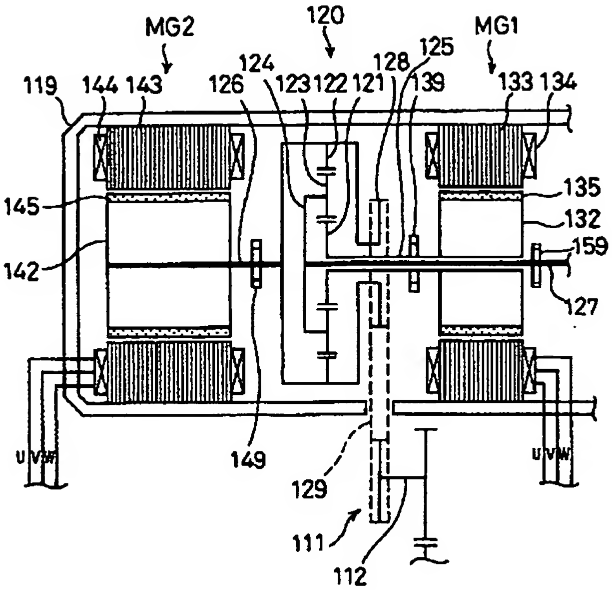
[Drawing 5]



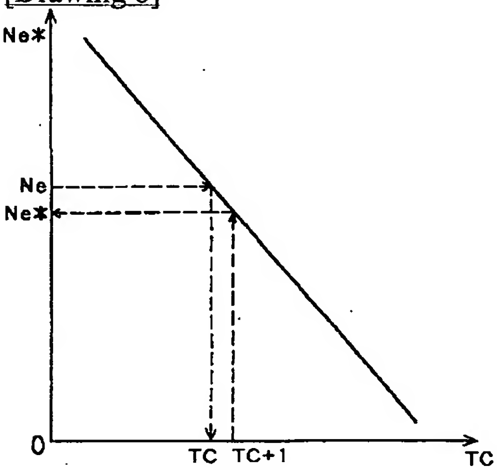
[Drawing 1]



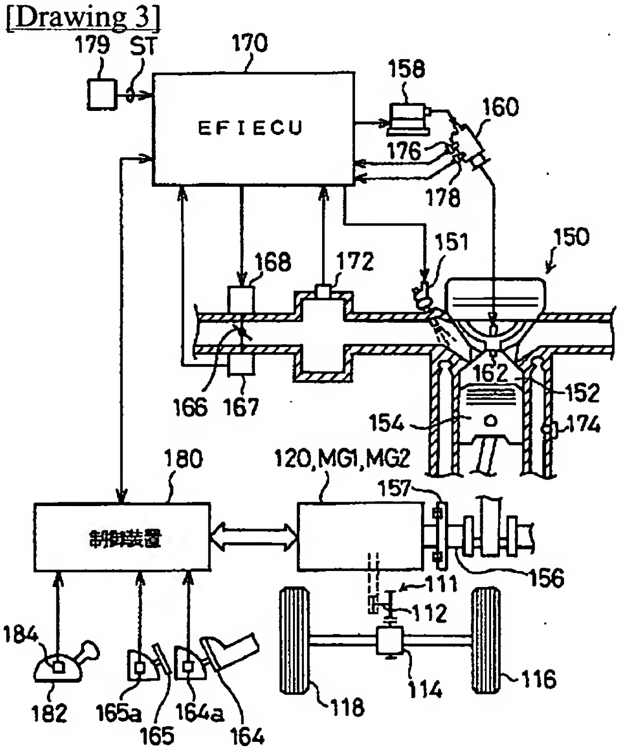
[Drawing 2]



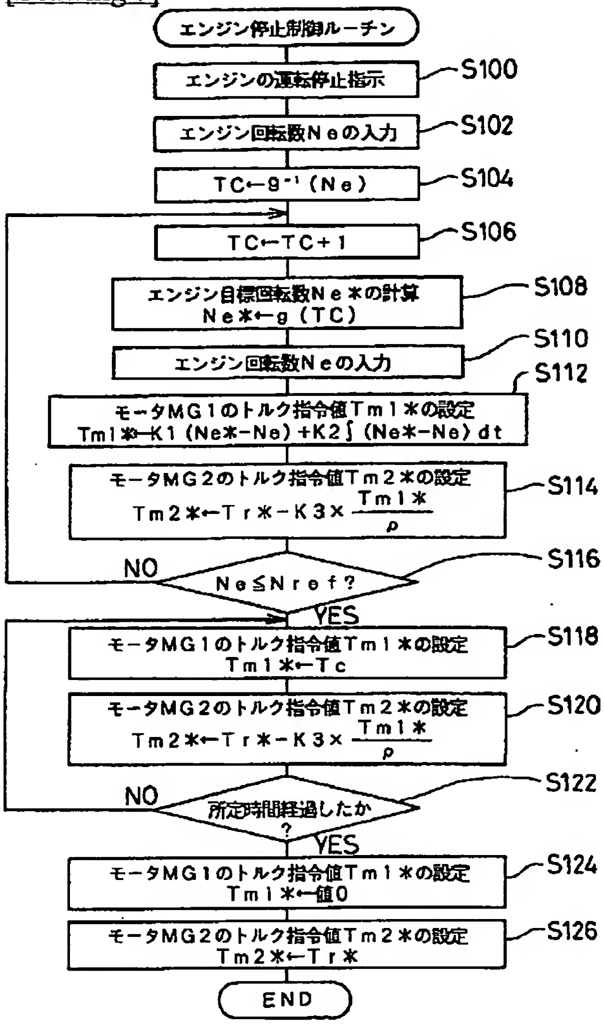
[Drawing 8]



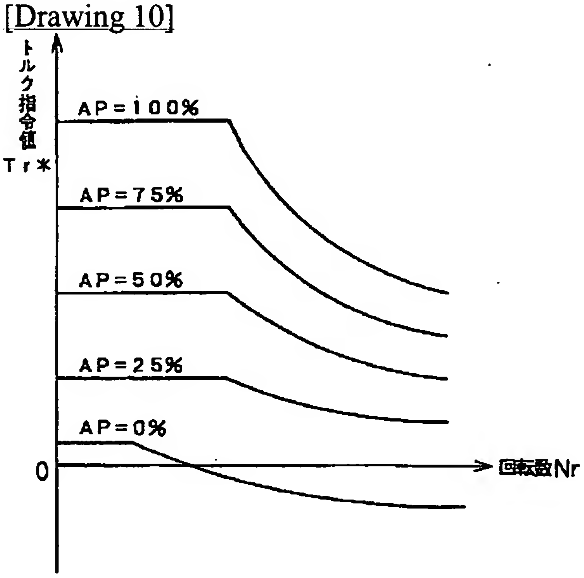
[Drawing 3]



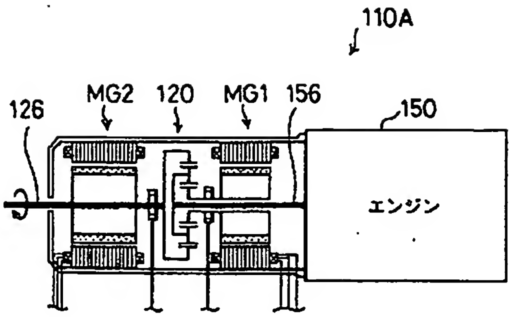
[Drawing 7]



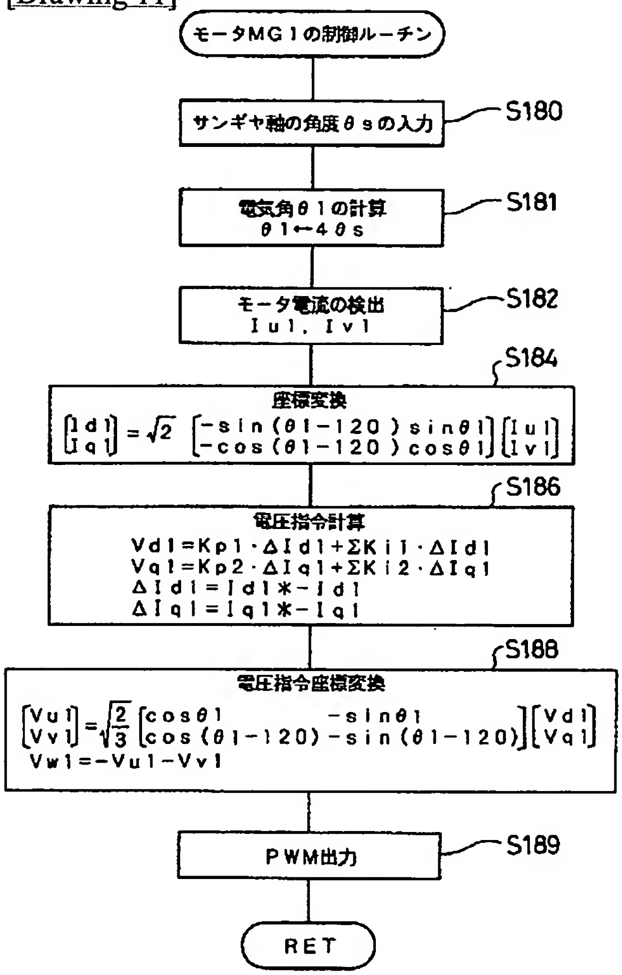
[Drawing 10]



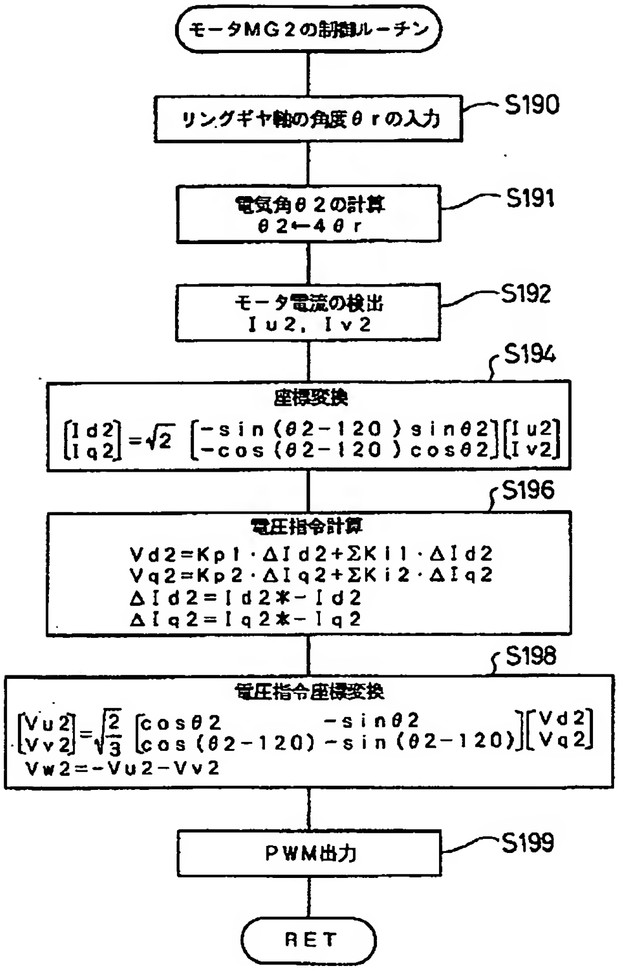
[Drawing 18]



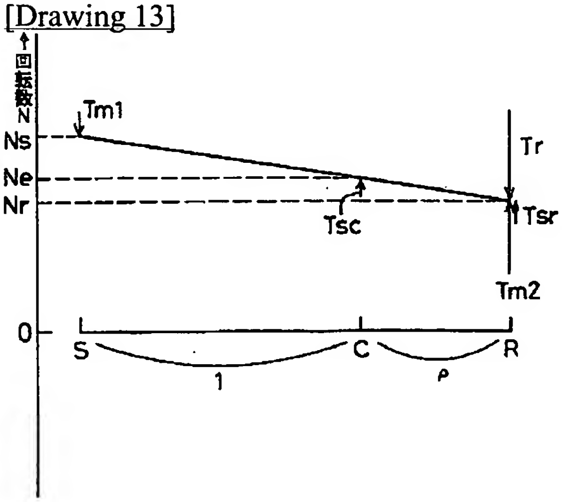
[Drawing 11]



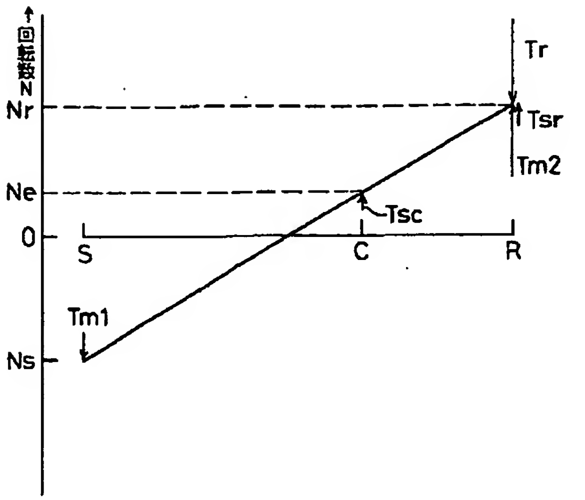
[Drawing 12]



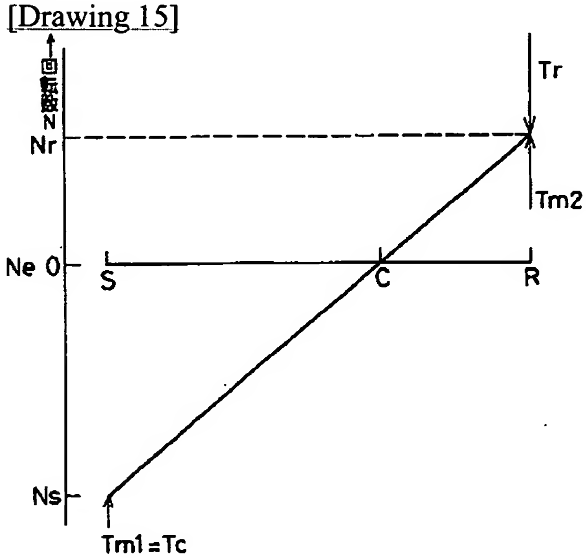
[Drawing 13]



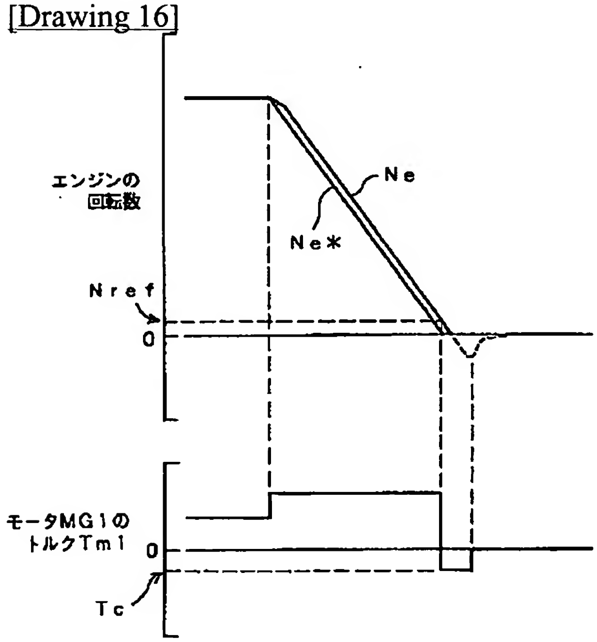
[Drawing 14]



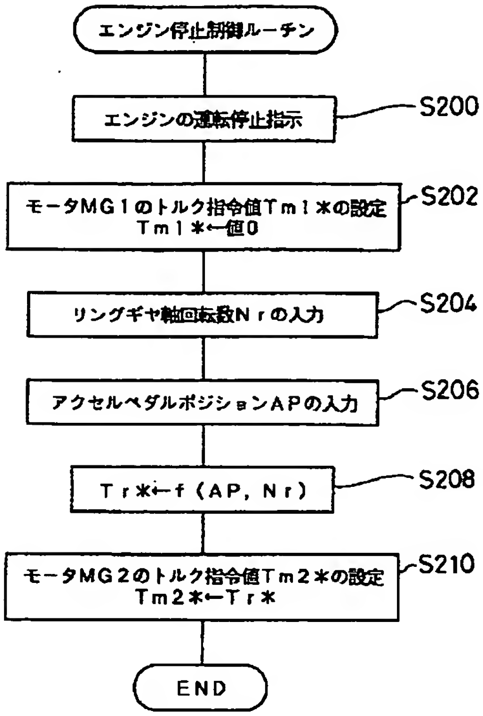
[Drawing 15]



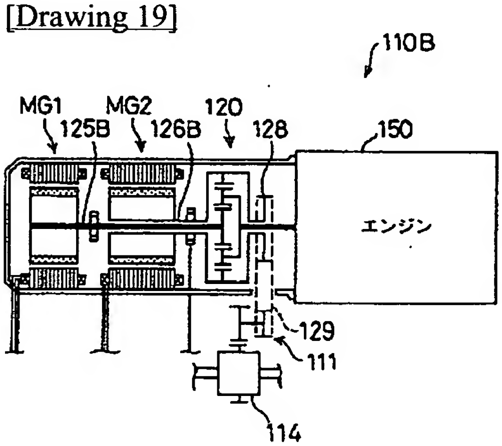
[Drawing 16]



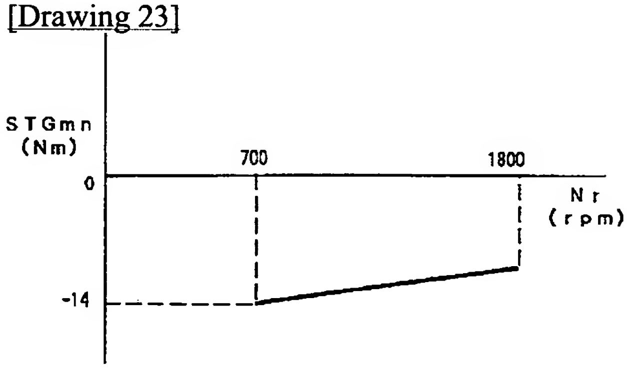
[Drawing 17]



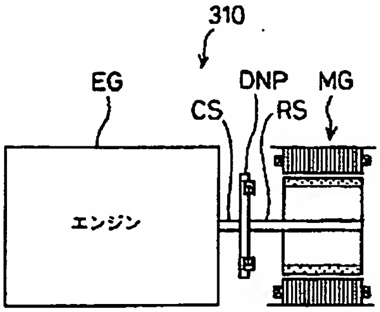
[Drawing 19]



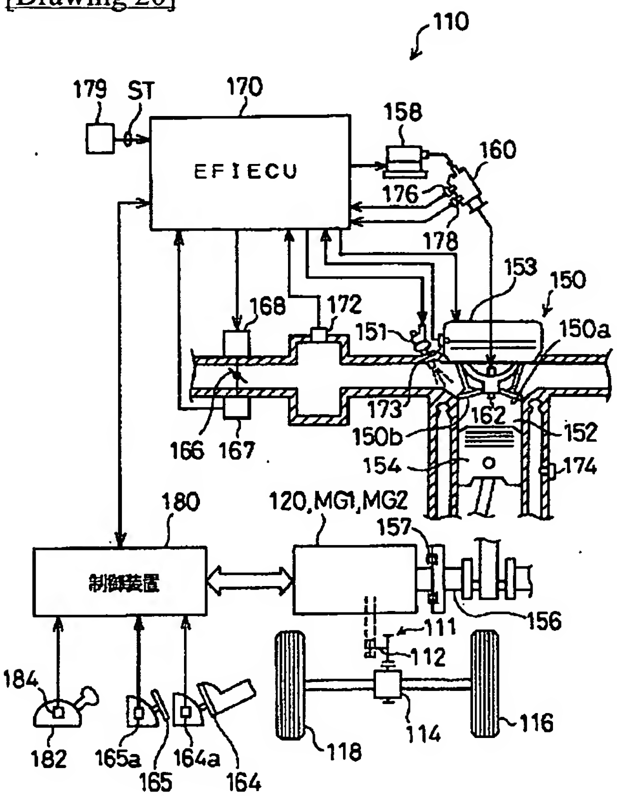
[Drawing 23]



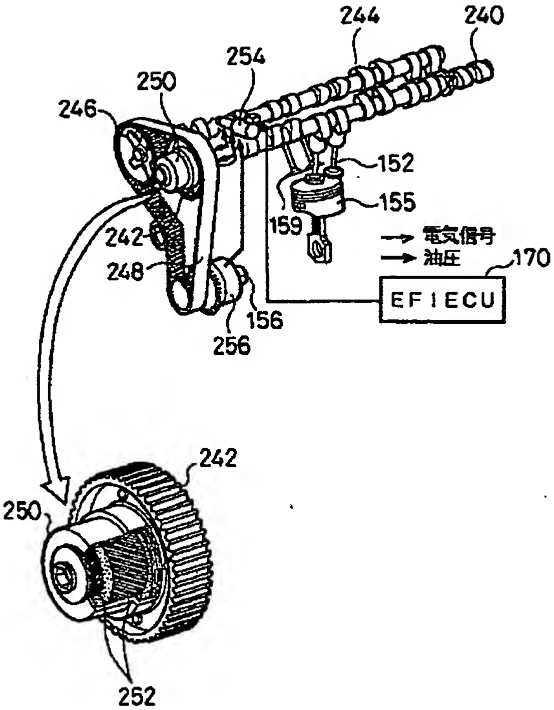
[Drawing 29]



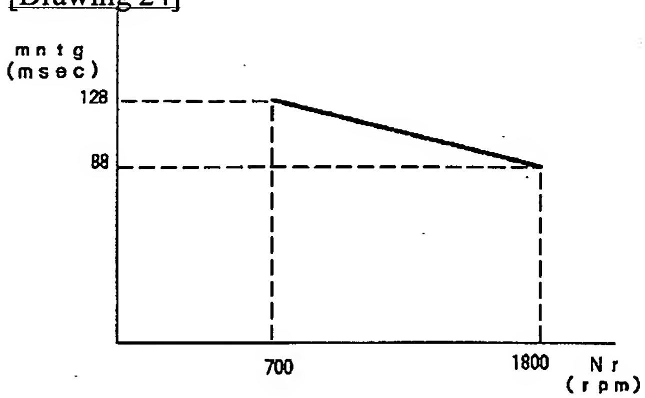
[Drawing 20]



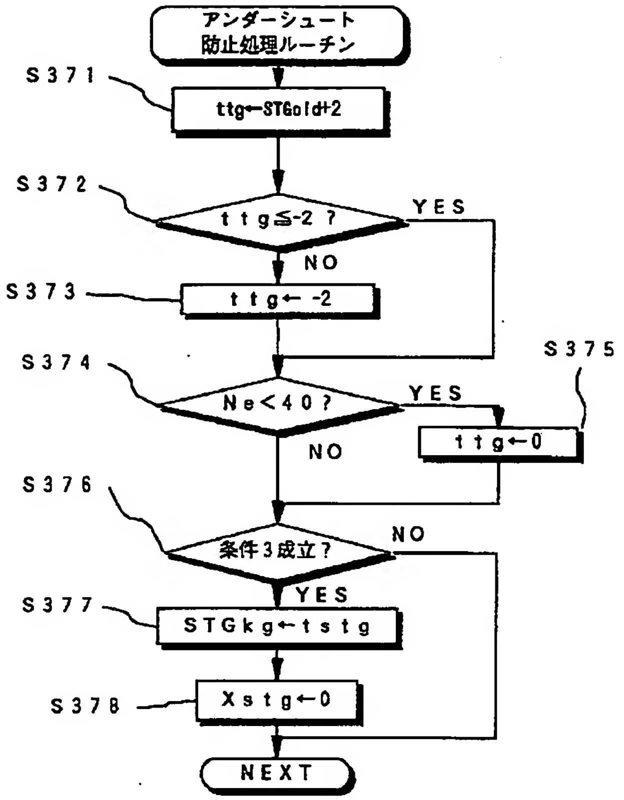
[Drawing 21]



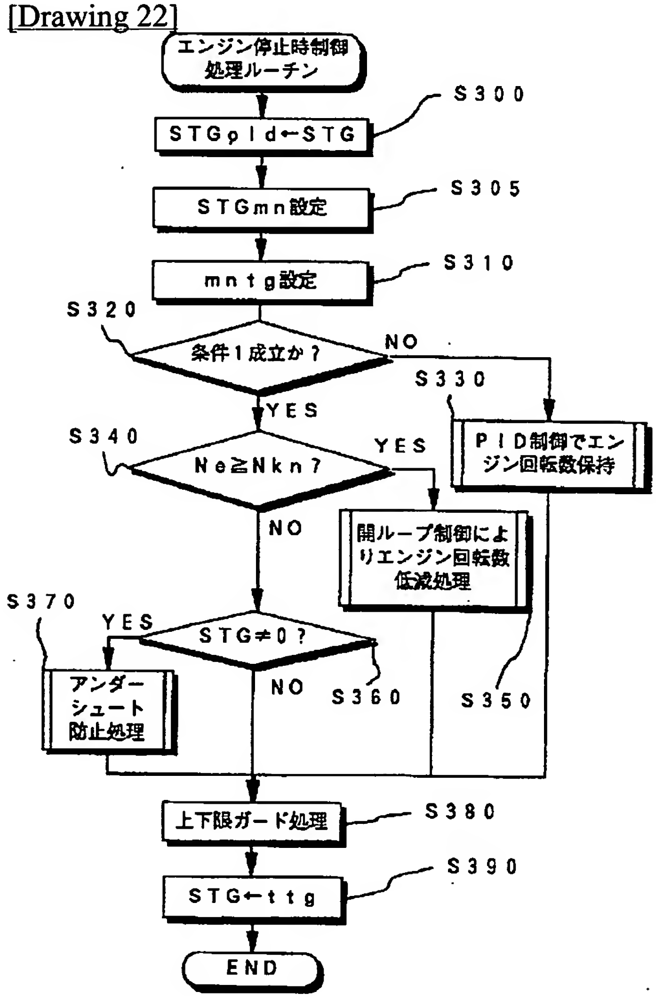
[Drawing 24]



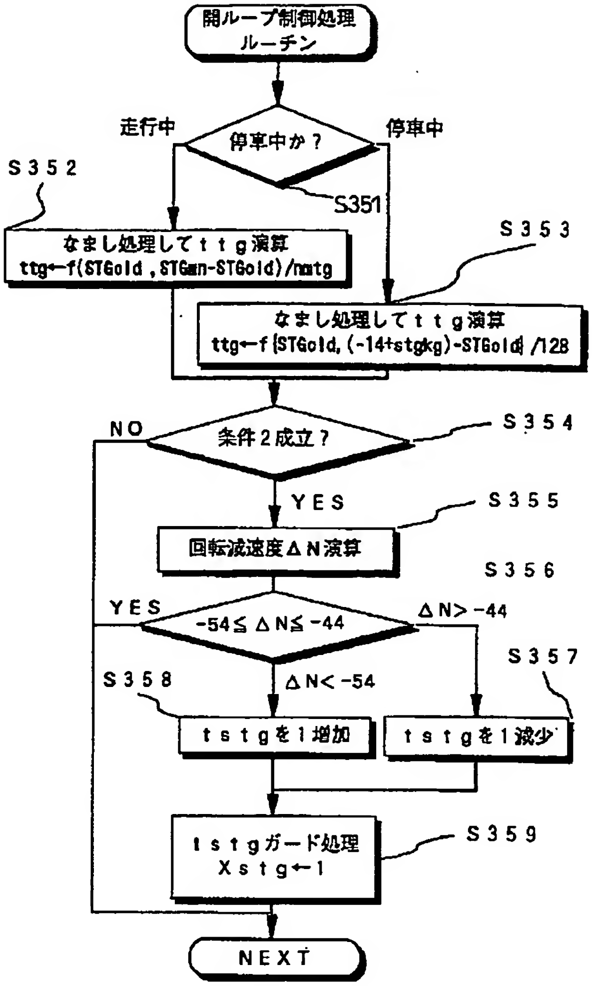
[Drawing 26]



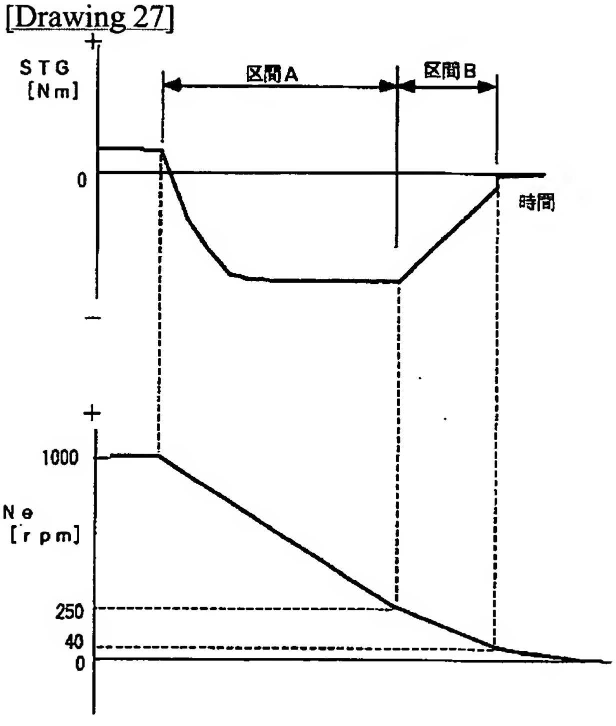
[Drawing 22]



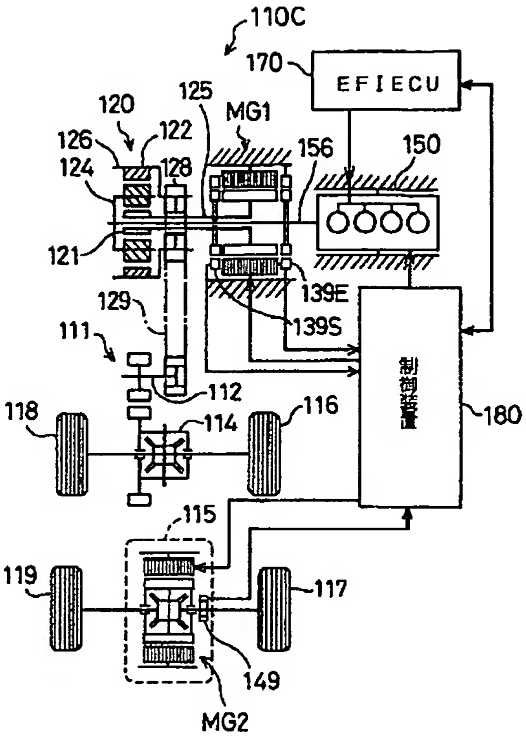
[Drawing 25]



[Drawing 27]



[Drawing 28]



[Translation done.]